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Industrial Source Complex (ISC) Dispersion Model User's Guide. Second Edition. Volume 1

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East Hartford, CT

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Volume I.

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16. ABSTRACT

The Second Edition of the Industrial Soruce Complex Dispersion (ISC) Model User's Guide provides a detailed technical discussion of the revised ISC Model. The ISC Model was designed in response to the need for a comprehensive set of dispersion model computer programs that could be used to evaluate the air quality impact of emissions from large industrial source complexes. Air quality impact analyses for industrial source complexes often require consideration of factors such as fugitive emissions, aerodynamic building wake effects, time-dependent exponential decay of pollutants, gravitational settling, and dry deposition. The ISC Model consists of two computer programs that are designed to consider these and other factors so as to meet the dispersion modeling needs of air pollution control agencies and others responsible for performing dispersion modeling analyses. Major features in the revised model code include: (1) a regulatory default option which incorporates regulatory guidance contained in the Guideline on Air Quality Models as revised in 1986; (2) a calms processing procedure; (3) a new Urban Mode 3 which utilizes urban dispersion parameters published by Briggs based on observations of McElroy and Pooler in St. Louis, and (4) revised sets of wind speed profile exponents for rural and urban scenarios.

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Volume I.

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SECTION 1

MODEL OVERVIEW

1.1 Introduction

EPA is involved in updating and revising air quality dispersion models for use in regulatory applications. The revisions are made to correct and improve technical features and to make the models more appropriate for specific applications. The Industrial Source Complex (ISC) Model has undergone several revisions since first being issued (Bowers, et al, 1979). This second edition of the ISC User's Guide has been prepared to provide the user with a full set of updated documentation describing the mathematical formulations and procedures for computer applications.

The new user's guide (an edited version of the first edition) is comprehensive and self-contained so that new users of ISC will not need to refer back to the original user's guide. Previous users of ISC will find the following new features:

- a third urban option which uses the Briggs fit, as contained in Gifford (1976), to the McElroy-Pooler urban dispersion coefficients
- an option for buoyancy induced dispersion
- a "regulatory default option" switch for use in regulatory applications
- an optional treatment for calm winds (only ISCST)
- a revised plume rise algorithm
- receptors at elevations below plant grade are treated in the same manner as receptors above plant grade
- revised default wind profile exponents for each rural and urban option
- computations for source-receptor distances less than 100 meters
- terrain truncation algorithm

- an option to print input data as soon as it is entered
- allowance for input of receptor elevations in feet or meters.
- allowance for printing of 3rd high tables.

Each of these new features is described more completely in Section 2.

1.2 Background and Purpose

Air quality impact analyses for pollutant sources other than emissions from isolated stacks often require consideration of factors such as fugitive emissions, aerodynamic wake effects, gravitational settling and dry deposition. The Industrial Source Complex (ISC) Dispersion Model consists of two computer programs that are designed to consider these and other factors so as to meet the needs of those who must perform complicated dispersion model analyses. The ISC Model computer programs are designed to be flexible, economical and as easy to use as possible without sacrificing the model features required to address complicated problems. Two evaluation studies of the ISC model have been published (Bowers and Anderson, 1981; Bowers et al., 1982).

Cautionary Note -- The ISC Model contains a number of options that are designed to consider complicated source configurations and special atmospheric effects. These options include: site-specific wind-profile exponents and vertical potential temperature gradients, time-dependent exponential decay of pollutants, stack-tip downwash, building wake effects, plume rise calculated as a function of downwind distance, buoyancy induced dispersion, and dry deposition. If one or more of these options is not specified by the user, the programs will assign preselected default values to various parameters. For regulatory applications, the use of the "regulatory default option" is recommended. If the user believes that the use of site-specific or source-specific parameters is appropriate, their use should be discussed with the responsible air pollution control agency prior to the model calculations. Also, because proper application of many of the ISC Model features requires a fundamental knowledge of the concepts of atmospheric transport and dispersion, the user should seek expert advice before using any ISC Model feature that is not fully understood. Finally, because a comprehensive model is required to address complicated problems, the ISC Model is not necessarily the model of choice for all applications. Simpler and less expensive computerized models such as the Single Source (CRSTER) Model (EPA, 1977) should be used for applications that do not require at least one of the ISC Model features.

The ISC Model computer programs are suitable for application to pollutant sources in the following types of studies:

- Stack design studies
- Combustion source permit applications
- Regulatory variance evaluation
- Monitoring network design
- Control strategy evaluation for SIP's
- Fuel (e.g., coal) conversion studies
- Control technology evaluation
- New source review
- Prevention of significant deterioration

1.3 General Description

The Industrial Source Complex (ISC) Dispersion Model combines and enhances various dispersion model algorithms into a set of two computer programs that can be used to assess the air quality impact of emissions from the wide variety of sources associated with an industrial source complex. For plumes comprised of particulates with appreciable gravitational settling velocities, the ISC Model accounts for the effects on ambient particulate concentrations of gravitational settling and dry deposition. Alternatively, the ISC Model can be used to calculate dry deposition. The ISC short-term model (ISCST), an extended version of the Single Source (CRSTER) Model (EPA, 1977), is designed to calculate concentration or deposition values for time periods of 1, 2, 3, 4, 6, 8, 12, and 24 hours. If used with a year of sequential hourly meteorological data, ISCST can also calculate annual concentration or deposition values. The ISC long-term model (ISCLT) is a sector-averaged model that extends and combines basic features of the Air Quality Display Model (AQDM) and the Climatological Dispersion model (CDM). The long-term model uses statistical wind summaries to calculate seasonal (quarterly) and/or annual ground-level concentration or deposition values. Both ISCST and ISCLT use either a polar or a Cartesian receptor grid. The ISC Model computer programs are written in Fortran 77 and require approximately 75,000 words of memory. The major features of the ISC Model are listed in Table 1-1.

The ISC Model programs accept the following source types: stack, area and volume. The volume source option is also used to simulate line sources. The steady-state Gaussian plume equation for a continuous source is used to calculate ground-level concentrations for stack and volume sources. The area source equation in the ISCST Model programs is based on the equation for a continuous and finite cross-wind line source. In the ISCLT Model program, the area source treatment uses a virtual point source approximation. The generalized Briggs (1969, 1971, 1972, 1973, 1975) plume-rise formulas are used to calculate final as well as gradual plume rise. Procedures suggested by Huber and Snyder (1976) and Huber (1977) are used to evaluate the effects of the aerodynamic wakes and eddies formed by buildings and other structures on plume dispersion. A wind-profile exponent law is used to adjust the observed mean wind speed from the measurement height to the emission height for the plume rise and concentration calculations. Procedures utilized by the Single Source (CRSTER) Model are used to account for variations in terrain height over the receptor grid. Except for Urban Mode 3, the Pasquill-Gifford curves

TABLE 1-1

MAJOR FEATURES OF THE ISC MODEL

Polar or Cartesian coordinate systems

Rural or one of three urban options

Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions (Briggs, 1969, 1971, 1972, 1973, and 1975)

Procedures suggested by Huber and Snyder (1976) and Huber (1977) for evaluating building wake effects.

Procedures suggested by Briggs (1974) for evaluating stack-tip downwash.

Separation of multiple point sources

Consideration of the effects of gravitational settling and dry deposition on ambient particulate concentrations

Capability of simulating point, line, volume and area sources

Capability to calculate dry deposition

Variation with height of wind speed (wind-profile exponent law)

Concentration estimates for 1-hour to annual average

Terrain-adjustment procedures for elevated terrain including a terrain truncation algorithm

Consideration of time-dependent exponential decay of pollutants

The method of Pasquill (1976) to account for buoyancy-induced dispersion.

A regulatory default option to set various model options and parameters to EPA recommended values.

Procedure for calm-wind processing

(Turner, 1970) are used to calculate lateral (σ_y) and vertical (σ_z) plume spread. The ISC Model has one rural and three urban options. In the Rural Mode, rural mixing heights* and the σ_y and σ_z values for the indicated stability category are used in the calculations. In Urban Mode 1, the stable E and F stability categories are redefined as neutral D stability. In Urban Mode 2, the E and F stability categories are combined and the σ_y and σ_z values for the stability category one step more unstable than the indicated stability category (except A) are used in the calculations (see Section 2.2.1.1). In Urban Mode 3, the Briggs urban dispersion coefficients derived from McElroy-Pooler observations are used. Urban mixing heights are used in all three urban modes.

1.4 System Description

1.4.1 The ISC Short-Term (ISCST) Model Program

Figure 1-1 is a schematic diagram of the ISC Model short-term computer program (ISCST). As shown by the figure, ISCST directly accepts the preprocessed meteorological data tape produced by the RAMMET preprocessor. This meteorological preprocessor program is described in the User's Manual for Single-Source (CRSTER) Model (EPA, 1977), as updated by Catalano (1986). Alternatively, hourly meteorological data may be input by card deck. Program control parameters, source data and receptor data are input by card deck. The program produces printouts of calculated concentration or deposition values.

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* The mixing height is the height above the surface at which an elevated stable layer restricts vertical mixing and confines pollutant emissions within the mixing layer.

1.4.2 The ISC Long-Term (ISCLT) Model Program

Figure 1-2 is a schematic diagram of the ISC Model long-term computer program (ISCLT). As shown by the figure, program control parameters, meteorological data, source data and receptor data are input by card deck. The program produces printouts of calculated concentration or deposition values. Additionally, all input data and the results of all calculations may be stored on an optional master tape inventory which can be used as input to update future runs. The master tape file stores the concentration or deposition calculated for each source at each receptor. Sources may be added, deleted or altered in update runs using card input for the affected sources. Concentration or deposition calculations are then made for those sources only and the concentration or deposition values calculated for each source are resummed to obtain an updated estimate of the concentration or deposition produced at each receptor by all sources.

1.5 Summary of Input Data

1.5.1 The ISC Short-Term (ISCST) Model Program

The input requirements for the ISC Model short-term computer program (ISCST) consist of four categories:

- Meteorological data
- Source data
- Receptor data
- Program control parameters

a. Meteorological Data. Meteorological inputs required by the ISCST program include hourly estimates of the wind direction, wind speed, ambient air temperature, Pasquill stability category, mixing height, wind-profile exponent and vertical potential temperature gradient. The magnetic tape

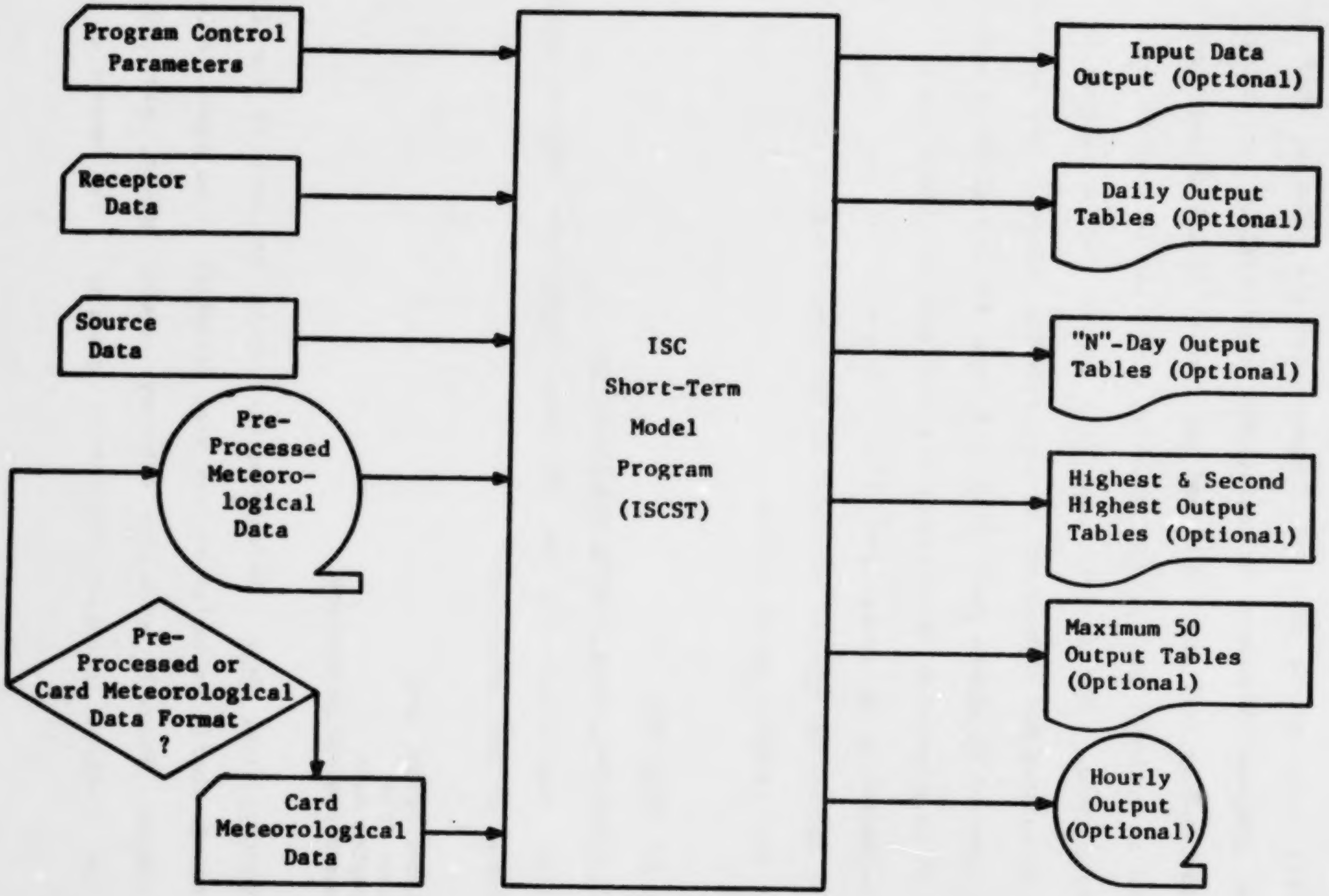
Program Control Parameters
Receptor Data
Source Data
Pre-Processed Meteorological Data
Pre-Processed or Card Meteorological Data Format ?
Card Meteorological Data
ISC Short-Term Model Program (ISCST)
Input Data Output (Optional)
Daily Output Tables (Optional)
"N"-Day Output Tables (Optional)
Highest & Second Highest Output Tables (Optional)
Maximum 50 Output Tables (Optional)
Hourly Output (Optional)

FIGURE 1-1. Schematic diagram of the ISC Model short-term computer program ISCST.

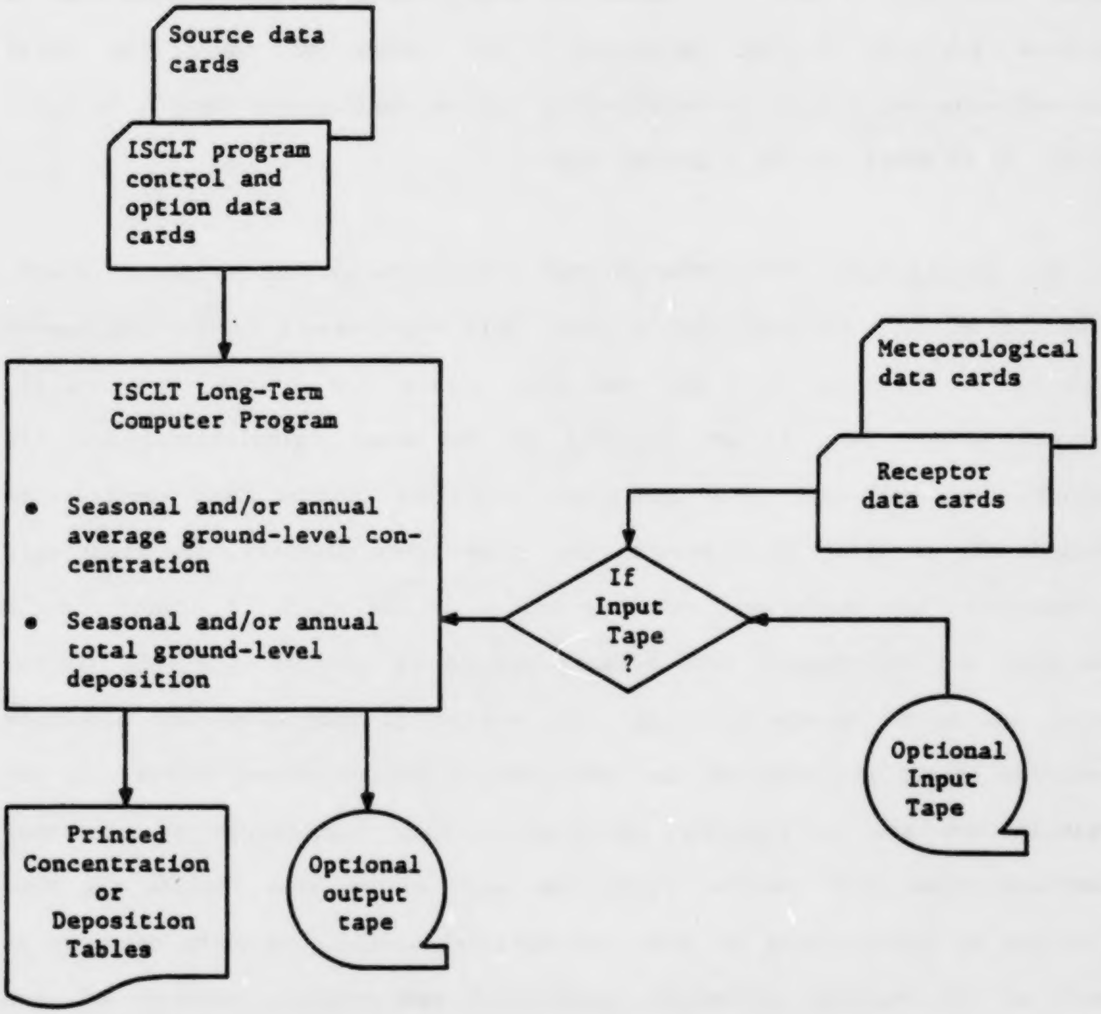
Source data cards
ISCLT program control and option data cards
ISCLT Long-Term Computer Program
• Seasonal and/or annual average ground-level concentration
• Seasonal and/or annual total ground-level deposition
Meteorological data cards
Receptor data cards
If Input Tape ?
Optional Input Tape
Printed Concentration or Deposition Tables
Optional output tape

FIGURE I-2. Schematic diagram of the ISC Model long-term computer program ISCLT.

output of the meteorological data preprocessor program and the program default values for the wind-profile exponent and the vertical potential temperature gradient satisfy all ISCST hourly meteorological data requirements. Alternatively, hourly meteorological data can be input by means of a card deck. When this is done, the use of the calm processing feature (described in Section 1.5.1.d) is not permitted. The number of hours for which concentration or deposition calculations can be made ranges from 1 to 8,784 (i.e., up to every hour of a 366-day year).

b. Source Data. The ISCST program accepts three source types: stack, area and volume. For each source, input data requirements include the source location with respect to a user-specified origin, the source elevation (if terrain effects are to be included in the model calculations) and the pollutant emission rate. For each stack, additional source input requirements include the physical stack height, the stack inner diameter, the stack exit temperature, the stack exit velocity and -- if the stack is adjacent to a building and aerodynamic wake effects are to be considered -- the length, width and height of the building. The horizontal dimensions and effective emission height are required for each area source or volume source. If the calculations are to consider particulates with appreciable gravitational settling velocities, source inputs for each source also include the mass fraction of particulates in each gravitational settling-velocity category as well as the surface reflection coefficient and settling velocity of each settling-velocity category. Because industrial pollutant emission rates are often highly variable, emission rates for each source may be held constant or varied as follows:

- By hour of the day
- By season or month
- By hour of the day and season
- By stability and wind speed (applies to fugitive sources of wind-blown particulates)

c. Receptor Data. The ISCST program uses either a polar (r, θ) or a Cartesian (X,Y) coordinate system. The typical polar receptor array consists of 36 radials (one for every 10 degrees of azimuth) and five to ten downwind ring distances for a total of 180 to 360 receptors. However, the user is not restricted to a 10-degree angular separation of receptors. The polar receptor array is always centered at X=0, Y=0. Receptor locations in the Cartesian coordinate system may be given as Universal Transverse Mercator (UTM) coordinates or as X (east-west) and Y (north-south) coordinates with respect to a user-specified origin. Discrete receptor points corresponding to the locations of air quality monitors, elevated terrain or other points of interest may also be used with either coordinate system. If terrain effects are to be included in the calculations, the elevation of each receptor is also required.

d. Program Control Parameters and Options. The ISCST program allows the user to select from a number of model options. The program parameters for these options are discussed in detail in Section 3.2.3. The available options include:

- Concentration/Deposition Option — Directs the program to calculate average concentration or total deposition

- Receptor Grid System Option -- Selects a Cartesian or a polar receptor grid system

- Discrete Receptor Option -- Allows the user to arbitrarily place receptors at any points using either a Cartesian or a polar coordinate system

- Receptor Terrain Elevation Option -- Allows the user to specify an elevation for each receptor (level terrain is assumed if this option is not exercised)

- Tape/file Output Option -- Directs the program to output the results of all concentration or deposition calculations to tape/file

- Print Input Data Option -- Directs the program to print program control parameters, source data and receptor data; the user may also direct the program to print the hourly meteorological data if this option is exercised. This option prints all input data after all input data has been read.

- Output Tables Option -- Specifies which of the five types of output tables are to be printed (see Section 3.1.3)

- Meteorological Data Option -- Directs the program to read hourly data from either the meteorological preprocessor format or a card image format. When card image format is selected, the calm processing feature, and the regulatory default option are not used.

- Rural/Urban Option -- Specifies whether the concentration or deposition calculations are made in the Rural Mode, Urban Mode 1, Urban Mode 2, or Urban Mode 3 (see Section 2.2.1.1)

- Wind-Profile Exponent Option -- Directs the program to read user-provided wind-profile exponents or to use the default values

- Vertical Potential Temperature Gradient Option -- Directs the program to read user-provided vertical potential temperature gradients or to use the default values

- Source Combination Option -- Allows the user to specify the combinations of sources for which concentration or deposition estimates are required

- Single Time Period Interval Option -- Directs the program to print concentration or deposition values for a specific time interval within a day (for example, the third 3-hour period)

- Variable Emission Rate Option -- Allows the user to specify scalars which are multiplied by the source's average emission rate; the scalars may vary by season or month, by hour of the day, by season and hour of the day, or by wind speed and stability

- Plume Rise as a Function of Distance Option -- Allows the user to direct the program to calculate plume rise as a function of downwind distance or to calculate final plume rise at all downwind distances

- Stack-Tip Downwash Option -- Allows the user to direct the program to use the Briggs (1974) procedures to account for stack-tip downwash for all stack sources

- Buoyancy-Induced Dispersion Option -- Allows the user to direct the program to use the Pasquill (1976) method to parameterize the growth of plumes during the plume rise phase

- Regulatory Default Option -- Allows the user to direct the program to use the following features generally recommended by EPA for regulatory applications:

  1) Tape/file meteorological input assumed
  2) Final plume rise at all receptor locations
  3) Stack-tip downwash
  4) Buoyancy-induced dispersion
  5) Default wind profile coefficients (urban or rural)
  6) Default vertical potential temperature gradients
  7) Calm wind processing
  8) A decay half life of 4 hours for SO_2, urban; otherwise the half life is set to infinity

  In ISCST all other options remain available to the user, except that if card image meteorological data input is used, the calm processing and regulatory default option features are not used.

- Calm Processing Option -- Allows the user to direct the program to exclude hours with persistent calm winds in the calculation of concentrations for each averaging period

- Terrain-truncation Algorithm -- Terrain is automatically truncated to an elevation of .005 meters below stack top when a receptor elevation exceeds stack top elevation

- Input Debug Option -- Directs the program to print input data as soon as it is read. This option is useful for debugging input data. Note, this option differs from the Print Input Data Option, which prints input data after all input data has been read

- Half-life -- A non-zero value directs the program to consider pollutant decay using the input half-life in seconds

- Wake Effects -- Non-zero values for source building dimensions automatically exercises the building wake effects option

1.5.2 The ISC Long-Term (ISCLT) Model Program

The input requirements for the ISC Model long-term computer program (ISCLT) consist of four categories:

- Meteorological data
- Source data
- Receptor data
- Program control parameters

Each of these data categories is discussed separately below.

a. Meteorological Data. Seasonal or annual "STAR" summaries (statistical tabulations of the joint frequency of occurrence of wind-speed and wind-direction categories, classified according to the Pasquill stability categories)* are the principal meteorological inputs to ISCLT. The program accepts STAR summaries with six Pasquill stability categories (A through F) or five stability categories (A through E with the E and F categories combined). ISCLT is not designed to use the Climatological Dispersion Model (CDM) STAR day/night summaries which subdivide the neutral D stability category into day and night D categories. Additional meteorological data requirements include seasonal average maximum and minimum heights and ambient air temperatures.

b. Source Data. The ISCLT source data requirements are the same as those given in the previous section for the ISCST program.

c. Receptor Data. The ISCLT receptor data requirements are the same as those given in the previous section for the ISCST program.

d. Program Control Parameters and Options. The ISCLT program allows the user to select from a number of model and logic options. The program control parameters for these options are discussed in detail in Section 4.2.3. The available options include:

- Concentration/Deposition Option -- Directs the program to calculate average concentration or total deposition
- Receptor Grid System Option -- Selects a Cartesian or a polar receptor grid system

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* STAR summaries are available from the National Climatic Data Center (NCDC), Asheville, North Carolina.

- Discrete Receptor Option -- Allows the user to place a receptor at any point using either a Cartesian or polar coordinate reference system

- Receptor Terrain Elevation Option -- Allows the user to specify an elevation for each receptor (level terrain is assumed by the program if this option is not exercised)

- Tape/File Input/Output Option -- Directs the program to input and/or output results of all concentration or deposition calculations, source data and meteorological data from and/or to magnetic tape or other data file

- Print Input Option -- Directs the program to print program control parameters, source data, receptor data and meteorological data. This option prints all input data after all input data has been read

- Print Seasonal/Annual Results Option -- Directs the program to print seasonal and/or annual concentration or deposition values, where seasons are normally defined as winter, spring, summer and fall

- Print Results from Individual/Combined Source Option -- Directs the program to print the concentration or deposition values for individual and/or combined sources, where the combined source output is the sum over a select group of sources or all sources

- Rural/Urban Option -- Specifies whether the concentration or deposition calculations are to be made in the Rural Mode, Urban Mode 1, Urban Mode 2, or Urban Mode 3 (see Section 2.2.1.1)

- Plume Rise as a Function of Distance Option -- Allows the user to direct the program to calculate plume rise as a function of downwind distance or to calculate final plume rise at all downwind distances

- Print Maximum 10/All Receptor Points Option -- Specifies whether the program is to print the maximum 10 concentration (deposition) values and receptors or to print the results of the calculations at all receptors without maximums or both

- Automatic Determination of Maximum 10 Option -- Directs the program to calculate the maximum 10 values of concentration (deposition) from the set of all receptors input; also, directs the program to display the 10 values of each contributing source at the locations determined by the maximum 10 values of the combined sources or to display the maximum 10 values and locations of each source individually

- User Specified Maximum 10 Option -- Allows the user the option of specifying up to 5 sets of 10 receptor points, one set for each seasonal and annual calculation or a single set of 10 receptor points, at which each source contribution as well as the total concentration (deposition) values for the combined sources are displayed

- Print Unit Option -- Allows the user to optionally direct the print output to any output device

- Tape/File Unit Option -- Allows the user to optionally select the logical unit numbers used for magnetic tape input and output

- Print Output Option -- This option is provided to minimize paper output; if selected, the program does not start a new page with each new table, but continues printing

- Lines per Page Option -- This option is provided to enable the user to specify the exact number of lines printed per page

- Size Options -- These are parameters that allow the user to specify the number of sources input via data card, the sizes of the X and Y receptor axes if used, the number of discrete receptor points if used, the number of seasons (or annual only) in the meteorological input data, and the number of wind-speed, Pasquill stability and wind-direction categories in the input meteorological data

- Combined Sources Option -- Allows the user the option of specifying, by source number, multiple sets of sources to use in forming combined sources output or the option of using all sources in forming combined sources output

- Units Option -- Allows the user the option of specifying the input emissions units and/or output concentration or deposition units

- Variable Emissions Option -- Allows the user the option of varying emissions by season, by wind speed and season, by Pasquill stability category and season or by wind speed, Pasquill stability category and season (season is either winter, spring, summer, fall or annual only)

- Stack-Tip Downwash Option -- Allows the user to direct the program to use the Briggs (1974) procedures for evaluating stack-tip downwash for all sources

- Buoyancy-Induced Dispersion Option -- Allows the user to direct the program to use the Pasquill (1976) method to parameterize the growth of plumes during the plume rise phase

- Regulatory Default Option -- Allows the user to direct the program to use the following features generally recommended by EPA for regulatory applications:

  1) Final plume rise at all receptor locations
  2) Stack-tip downwash
  3) Buoyancy-induced dispersion
  4) Default wind profile coefficients (urban or rural)
  5) Default vertical potential temperature gradients
  6) A decay half life of 4 hours for SO_2, urban; otherwise the decay half life is set to infinity

In ISCLT, all other options remain available to the user under the regulatory default option.

- Terrain-truncation Option -- Terrain is automatically truncated to an elevation of .005 meters below stack top when a receptor elevation exceeds stack top elevation
- Input Debug Option -- Directs the program to print input data as soon as it is read. This option is useful for debugging input data. Note, this option differs from the Print Input Data Option, which prints input data after all input data has been read

SECTION 2

TECHNICAL DESCRIPTION

2.1 General

The Industrial Source Complex (ISC) Dispersion Model is an advanced Gaussian plume model. The technical discussion contained in this section assumes that the reader is already familiar with the theory and concepts of Gaussian plume models. Readers who lack a fundamental knowledge of the basic concepts of Gaussian plume modeling are referred to Section 2 of the User's Manual for the Single Source (CRSTER) Model (EPA, 1977 and Catalano, 1986) or to other references such as Atmospheric Science and Power Production (Randerson, 1984) or the Workbook of Atmospheric Dispersion Estimates (Turner, 1970).

2.2 Model Input Data

2.2.1 Meteorological Input Data

2.2.1.1 Meteorological Inputs for the ISC Short-Term (ISCST) Model Program

Table 2-1 gives the hourly meteorological inputs required by the ISC Model short-term computer program (ISCST). These inputs include the mean wind speed measured at height z_1, the direction toward which the wind is blowing, the wind-profile exponent, the ambient air temperature, the Pasquill stability category, the vertical potential temperature gradient and the mixing layer height. In general, these inputs are developed from concurrent surface and upper-air meteorological data by the RAMMET preprocessor program as used by the Single Source (CRSTER) Model (EPA, 1977 and Catalano, 1986). If the preprocessed meteorological data are used, the user may input, for each combination of wind-speed and Pasquill stability categories, site-specific values of the wind-profile exponent and the vertical potential temperature

TABLE 2-1

HOURLY METEOROLOGICAL INPUTS REQUIRED BY THE ISC SHORT-TERM MODEL PROGRAM

Parameter	Definition
$\bar{u}_1$	Mean wind speed in meters per second (m/sec) at height z_1 (default value for z_1 is 10 meters)
AFVR	Average random flow vector (direction toward which the wind is blowing)
p	Wind-profile exponent (default values assigned on the basis of stability; see Table 2-2)
T_a	Ambient air temperature in degrees Kelvin (°K)
H_m	Depth of surface mixing layer (meters), developed from twice-daily mixing height estimates by the meteorological preprocessor program
Stability	Pasquill stability category (1 = A, 2 = B, etc.)
$\frac{\partial\theta}{\partial z}$	Vertical potential temperature gradient in degrees Kelvin per meter (default values assigned on the basis of stability category; see Table 2-2)

TABLE 2-2

DEFAULT VALUES FOR THE WIND-PROFILE EXPONENTS AND VERTICAL POTENTIAL TEMPERATURE GRADIENTS

Pasquill Stability Category	Urban Wind-Profile Exponent p	Rural Wind-Profile Exponent p	Vertical Potential Temperature Gradient (°K/m)
A	0.15	0.07	0.000
B	0.15	0.07	0.000
C	0.20	0.10	0.000
D	0.25	0.15	0.000
E	0.30	0.35	0.020
F	0.30	0.55	0.035

gradient. If the user does not input site-specific wind-profile exponents and vertical potential temperature gradients, the ISC Model uses the default values given in Table 2-2. The inputs listed in Table 2-1 may also be developed by the user from observed hourly meteorological data and input by card deck. In these cases, the direction from which the wind is blowing must be reversed 180 degrees to conform with the average flow vector (the direction toward which the wind is blowing) generated by the meteorological preprocessor program.

It should be noted that concentrations calculated using Gaussian dispersion models are inversely proportional to the mean wind speed and thus the calculated concentrations approach infinity as the mean wind speed approaches zero (calm). Also, there is no basis for estimating wind direction during periods of calm winds. The meteorological preprocessor program arbitrarily sets the wind speed equal to 1 meter per second if the observed wind speed is less than 1 meter per second and, in the case of calm winds, sets the wind direction equal to the value reported for the last non-calm hour. EPA has developed a procedure for treating these periods of calm winds. The procedure is available in ISCST as a user-defined option. With this option selected, calm processing is performed if the program encounters two consecutive hours which have the same unrandomized wind direction, and the wind speed of the latter hour is equal to 1.0 meter per second. The program sets the concentration equal to 0.0 at all receptors when calms are identified. The routine then recalculates concentrations for each averaging time using the sum of non-calm hour concentrations divided by the number of non-calm hours in the period. The denominator (number of non-calm hours in the period) is limited to a minimum value of 2, 3, 3, 4, 6, 9, and 18 hours for the 2, 3, 4, 6, 8, 12, and 24 hour averaging periods, respectively. Because unrandomized wind directions are necessary for use with the calm processing routine, the model will not allow the calm processing option when meteorology is input with cards.

The ISCST program also allows for the use of the calm processing option when run in the deposition mode. In this case, a minimum divisor is not used. Simply, if an hour is determined as being calm, depositions for all source-receptor pairs are set to 0 for this hour.

The ISCST program has a rural and three urban options. In the Rural Mode, rural mixing heights and the Pasquill Gifford (P-G) σ_y and σ_z values for the indicated stability category are used in the calculations. Urban mixing heights are used in the urban modes. In Urban Mode 1, the stable E and F categories are redefined as neutral (D) stability, and the P-G σ_y and σ_z values are used. In Urban Mode 2, the E and F stability categories are combined and the P-G σ_y and σ_z values for the stability category one step more unstable than the indicated category are used in the calculations. For example, the P-G σ_y and σ_z values for C stability are used in calculations for D stability in Urban Mode 2. In Urban Mode 3, stability categories are not combined, but urban dispersion curves of Briggs are used. These curves, as reported by Gifford (1976), where derived from the St. Louis Dispersion Study (McElroy-Pooler, 1968). Table 2-3 gives the dispersion coefficients used in each mode.

The Rural Mode is usually selected for industrial source complexes located in rural areas. However, the urban options may also be considered in modeling an industrial source complex located in a rural area if the source complex is large and contains numerous tall buildings and/or large heat sources (for example, coke ovens). An urban mode is appropriate for these cases in order to account for the enhanced turbulence generated during stable meteorological conditions by the surface roughness elements and/or heat sources. If an urban mode is appropriate, Urban Mode 3 is recommended by EPA for regulatory

TABLE 2-3

PASQUILL STABILITY CATEGORIES USED BY THE ISC MODEL TO SELECT DISPERSION COEFFICIENTS FOR THE RURAL AND URBAN MODES

Actual Pasquill Stability Category*	Pasquill Stability Category for the σ_y, σ_z Values Used in ISC Model Calculations			
	Rural Mode	Urban Mode 1	Urban Mode 2	Urban Mode 3**
A	A	A	A	A
B	B	B	A	B
C	C	C	B	C
D	D	D	C	D
E	E	D	D	E
F	F	D	D	F

* The ISCST program redefines extremely stable G stability as very stable F stability.

** The Briggs urban dispersion curves combine A and B into one "very unstable" category, and E and F into one "stable" category.

applications. Modes 1 and 2 are generally not used but are available to the user for historical interest and model evaluation.

2.2.1.2 Meteorological Inputs for the ISC Long-Term (ISCLT) Model Program

Table 2-4 lists the meteorological inputs required by the ISC Model long-term computer program (ISCLT). Seasonal or annual STAR summaries are the principal meteorological inputs to the ISCLT program. A STAR summary is a tabulation of the joint frequency of occurrence of wind-speed and wind-direction categories, classified according to the Pasquill stability categories. Table 2-5 identifies the combinations of wind-speed and Pasquill stability categories that are possible following the Turner (1964) procedures of using airport surface weather observations to estimate atmospheric stability. The wind-speed categories in Table 2-5 are in knots because the National Weather Service (NWS) reports airport wind speeds to the nearest knot. The default values of the wind speeds in meters per second, and knots, assigned by ISCLT to each wind-speed category are shown at the bottom of Table 2-5. The sixteen standard 22.5-degree wind-direction sectors used in STAR summaries are shown in Figure 2-1. ISCLT accepts STAR summaries with six stability categories (A through F) or five stability categories (A through E with the E and F categories combined). ISCLT is not designed to use the Climatological Dispersion Model (CDM) STAR summaries which divide the neutral D stability category into day and night D categories. STAR summaries are available for most NWS surface weather stations from the National Climatic Data Center (NCDC).

The ISCLT user must specify ambient air temperatures by stability and season and mixing heights by stability and/or wind-speed and season. It is suggested that the average seasonal maximum daily temperature be assigned to the A, B and C stability categories; the average seasonal minimum daily

TABLE 2-4

METEOROLOGICAL INPUTS REQUIRED BY THE ISC LONG-TERM MODEL PROGRAM

Parameter	Definition
$f_{i,j,k,\ell}$	Frequency of occurrence of the i^{th} wind-speed category and j^{th} wind-direction category by stability category k for the ℓ^{th} season (STAR summary)
$\bar{u}_i$	Mean wind speed in meters per second (m/sec) at height z_1 for each wind-speed category (default values based on STAR wind-speed categories)
$p_{i;k}$	Wind-profile exponent for each combination of wind-speed and stability categories (default values are assigned on the basis of stability; see Table 2-2)
$T_{a;k,\ell}$	Ambient air temperature for the k^{th} stability category and ℓ^{th} season in degrees Kelvin (°K)
$\partial\theta/\partial z_{i,k}$	Vertical potential temperature gradient in degrees Kelvin per meter (°K/m) for each combination of wind-speed and stability categories (default values are assigned on the basis of stability category; see Table 2-2)
$H_{m;i,k,\ell}$	Mixing height in meters for the i^{th} wind-speed category, k^{th} stability category and ℓ^{th} season

TABLE 2-5

POSSIBLE COMBINATIONS OF WIND-SPEED AND PASQUILL STABILITY CATEGORIES* AND MEAN WIND SPEEDS IN EACH NCDC STAR SUMMARY WIND-SPEED CATEGORY

Pasquill Stability Category	Wind Speed (kt) 0-3	4-6	7-10	11-16	17-21	>21
A	X	X				
B	X	X	X			
C	X	X	X	X	X	X
D	X	X	X	X	X	X
E		X	X			
F	X	X				
ISCLT Wind Speed						
(m/sec)	1.50	2.50	4.30	6.80	9.50	12.50
(knots)	2.91	4.86	8.35	13.21	18.45	24.28

* Based on Turner (1964) definitions of the Pasquill stability categories.

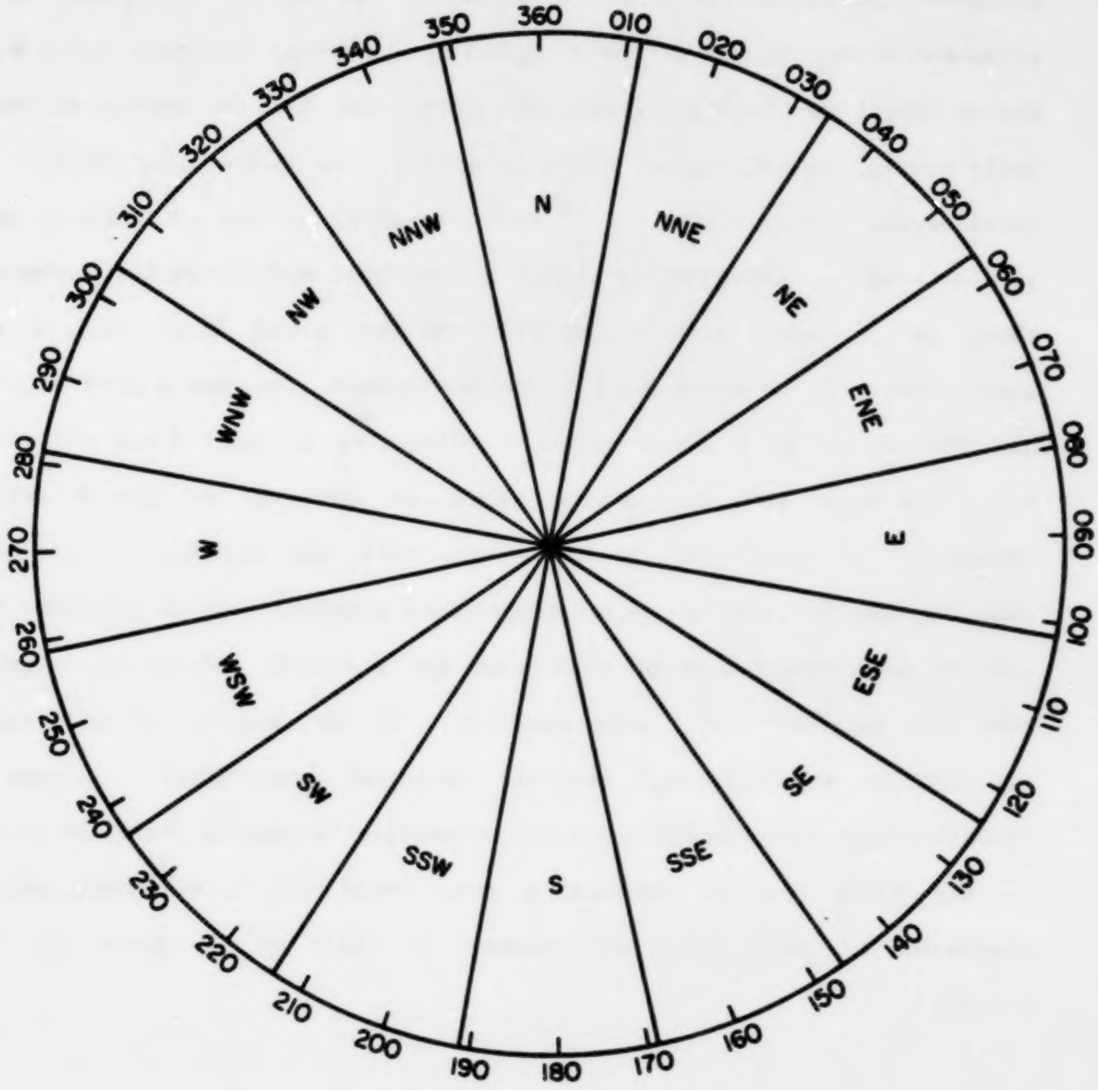

360
010
020
030
040
050
060
070
080
090
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW

FIGURE 2-1. **The sixteen standard 22.5-degree wind direction sectors used in STAR summaries.**

temperature be assigned to the E and F stability categories; and the average seasonal temperature be assigned to the D stability category. In urban areas, common practice is to assign the mean afternoon mixing height given by Holzworth (1972) to the B and C stability categories, 1.5 times the mean afternoon mixing height to the A stability category, the mean early morning mixing height to the E and F stability categories, and the average of the mean early morning and afternoon mixing heights to the D stability category. In rural areas, the applicability of Holzworth early morning urban mixing heights is questionable. Consequently, ISCLT in the Rural Mode currently assumes that there is no restriction on vertical mixing during hours with E and F stabilities. It is suggested that Holzworth mean afternoon mixing heights be assigned to the B, C and D stability categories in rural areas and that 1.5 times the mean afternoon mixing height be assigned to the A stability category. If sufficient climatological data are available, wind-profile exponents and vertical potential temperature gradients can be assigned by the user to each combination of wind-speed and stability categories in order to make the long-term model site specific. In the absence of site-specific wind-profile exponents and vertical potential temperature gradients, the default values given in Table 2-2 are automatically used by the ISCLT program.

The ISCLT program contains a rural mode and three urban modes. A discussion of these modes and guidance on their use is given in Section 2.2.1.1.

2.2.2 Source Input Data

Table 2-6 summarizes the source input data requirements of the ISC Dispersion Model computer programs. As shown by the table, there are three source types: stack, volume and area. The volume source option is also used to simulate line sources. Source elevations above mean sea level and source

TABLE 2-6

SOURCE INPUTS REQUIRED BY THE ISC MODEL PROGRAMS

Parameter	Definition
Stacks	
Q	Pollutant emission rate for concentration calculations (mass per unit time)
Q_τ	Total pollutant emissions during the time period τ for which deposition is calculated (mass)
ψ	Pollutant decay coefficient (seconds^{-1})
X, Y	X and Y coordinates of the stack (meters)
Z_s	Elevation of base of stack (meters above mean sea level)
h	Stack height (meters)
v_s	Stack exit velocity (meters per second)
d	Stack inner diameter (meters)
T_s	Stack exit temperature (degrees Kelvin)
ϕ_n	Mass fraction of particulates in the n^{th} settling-velocity category
V_{sn}	Gravitational settling velocity for particulates in the n^{th} settling-velocity category (meters per second)
γ_n	Surface reflection coefficient for particulates in the n^{th} settling-velocity category
h_b	Height of building adjacent to the stack (meters)
W	Width of building adjacent to the stack (meters)
L	Length of building adjacent to the stack (meters)
Volume Source (Line Source)	
Q	Same definition as for stacks
Q_τ	Same definition as for stacks
ψ	Same definition as for stacks

TABLE 2-6
(CONTINUED)

SOURCE INPUTS REQUIRED BY THE ISC MODEL PROGRAMS

Parameter	Definition
Volume Source (Line Source) (Continued)	
X, Y	X and Y coordinates of the center of the volume source or of each volume source used to represent a line source (meters)
Z_s	Elevation of the ground surface at the point of the center of each volume source (meters above mean sea level)
H	Height of the center of each volume source above the ground surface (meters)
σ_{yo}	Initial horizontal dimension (meters)
σ_{zo}	Initial vertical dimension (meters)
ϕ_n	Same definition as for stacks
V_{sn}	Same definition as for stacks
γ_n	Same definition as for stacks
Area Source	
Q_A	Pollutant emission rate for concentration calculations (mass per unit time per unit area)
$Q_{A\tau}$	Total pollutant emissions during the time period τ for which deposition is calculated (mass per unit area)
ψ	Same definition as for stacks
X, Y	X and Y coordinates of the southwest corner of the square area source (meters)
Z_s	Elevation of the area source (meters above mean sea level)
H	Effective emission height of the area source (meters)
x_o	Width of the square area source (meters)
ϕ_n	Same definition as for stacks
V_{sn}	Same definition as for stacks
γ_n	Same definition as for stacks

locations with respect to a user-specified origin are required for all sources. If the Universal Transverse Mercator (UTM) coordinate system is used to define receptor locations, UTM coordinates can only be used to define source locations if a Cartesian receptor array is used. With a polar receptor array, the origin is at (X=0, Y=0). The X and Y coordinates of the other sources with respect to this origin are then obtained from a plant layout drawn to scale. The x axis is positive to the east and the y axis is positive to the north. Note that the origin of the polar receptor array is always at X=0, Y=0.

The pollutant emission rate is also required for each source. If the pollutant is depleted by any mechanism that can be described by time-dependent exponential decay, the user may enter a decay coefficient ψ. Note that if SO_2 is modelled in the urban mode, and the regulatory default option is chosen, a decay half life of 4 hours is automatically assigned. The parameters ϕ_n, V_{sn}, and γ_n are only input if concentration or deposition calculations are being made for particulates with appreciable gravitational settling velocities (diameters greater than about 20 micrometers). Particulate emissions from each source can be divided by the user into a maximum of 20 gravitational settling-velocity categories. Emission rates used by the short-term model program ISCST may be held constant or may be varied as follows:

- By hour of the day
- By season or month
- By hour of the day and season
- By wind-speed and stability categories (applies to fugitive sources of wind-blown dust)

Emission rates used by the long-term model program ISCLT may be annual average rates or may be varied by season or by wind-speed and stability categories.

Additional source inputs required for stacks include the physical stack height, the stack exit velocity, the stack inner diameter, and the stack exit temperature. For an area source or a volume source, the dimensions of the source and the effective emission height are entered in place of these parameters. If a stack is located on or adjacent to a building and the stack height to building height ratio is less than 2.5, the length (L) and width (W) of the building are required as source inputs in order to include aerodynamic wake effects in the model calculations. The building wake effects option is automatically exercised if building dimensions are entered.

2.2.3 Receptor Data

The ISC Dispersion Model computer programs allow the user to select either a Cartesian (X, Y) or a polar (r, θ) receptor grid system. In the Cartesian system, the x-axis is positive to the east of a user-specified origin and the y-axis is positive to the north. In the polar system, r is the radial distance measured from the origin (X=0, Y=0) and the angle θ (azimuth bearing) is measured clockwise from north. If the industrial source complex is comprised of multiple sources that are not located at the same point, a Cartesian coordinate system is usually more convenient than the polar coordinate system. Additionally, if the Universal Transverse Mercator (UTM) coordinate system is used to define source locations and/or to extract the elevations of receptor points from USGS topographic maps, the UTM system can also be used in the ISC Model calculations. Discrete (arbitrarily placed) receptor points corresponding to the locations of air quality monitors, elevated terrain features, the property boundaries of the industrial source complex or other points of interest can be used with either coordinate system.

In the polar coordinate system, receptor points are usually spaced at 10-degree intervals on concentric rings. Thus, there are 36 receptors on each ring. The radial distances from the origin to the receptor rings are user selected and are generally set equal to the distances to the expected maximum ground-level concentrations for the major pollutant sources under the most frequent stability and wind-speed combinations. Estimates of these distances can be obtained from the PTPLU computer program (Pierce and Turner, 1982) or from preliminary calculations using the ISCST computer program. The maximum number of receptor points is determined by factors such as the number of sources and the desired output (see Equation (3-1) for the short-term model and Equations (4-1), (4-2), and (4-3) for the long-term model). An example of a polar receptor array is shown in Figure 2-2.

In the Cartesian coordinate system, the X and Y coordinates of the receptors are specified by the user. The spacing of grid points is not required to be uniform so that the density of grid points can be greatest in the area of the expected maximum ground-level concentrations. For example, assume that an industrial source complex is comprised of a number of major sources, contained within a 1-kilometer square, whose maximum ground-level concentrations are expected to occur at downwind distances ranging from 500 to 1000 meters. The Cartesian receptor grid (X and Y = 0, ±200, ±400, ±600, ±800, ±1000, ±1200, ±1500, ±2000, ±3000) illustrated in Figure 2-3 provides a dense spacing of grid points in the areas where the highest concentrations are expected to occur. As shown by Figure 2-3, use of the Cartesian system requires that some of the receptor points be located within the property of the source complex. If a receptor is located within 1 meter of a source, or within 3 building heights (or 3 building widths, if the width is less than the height) of a

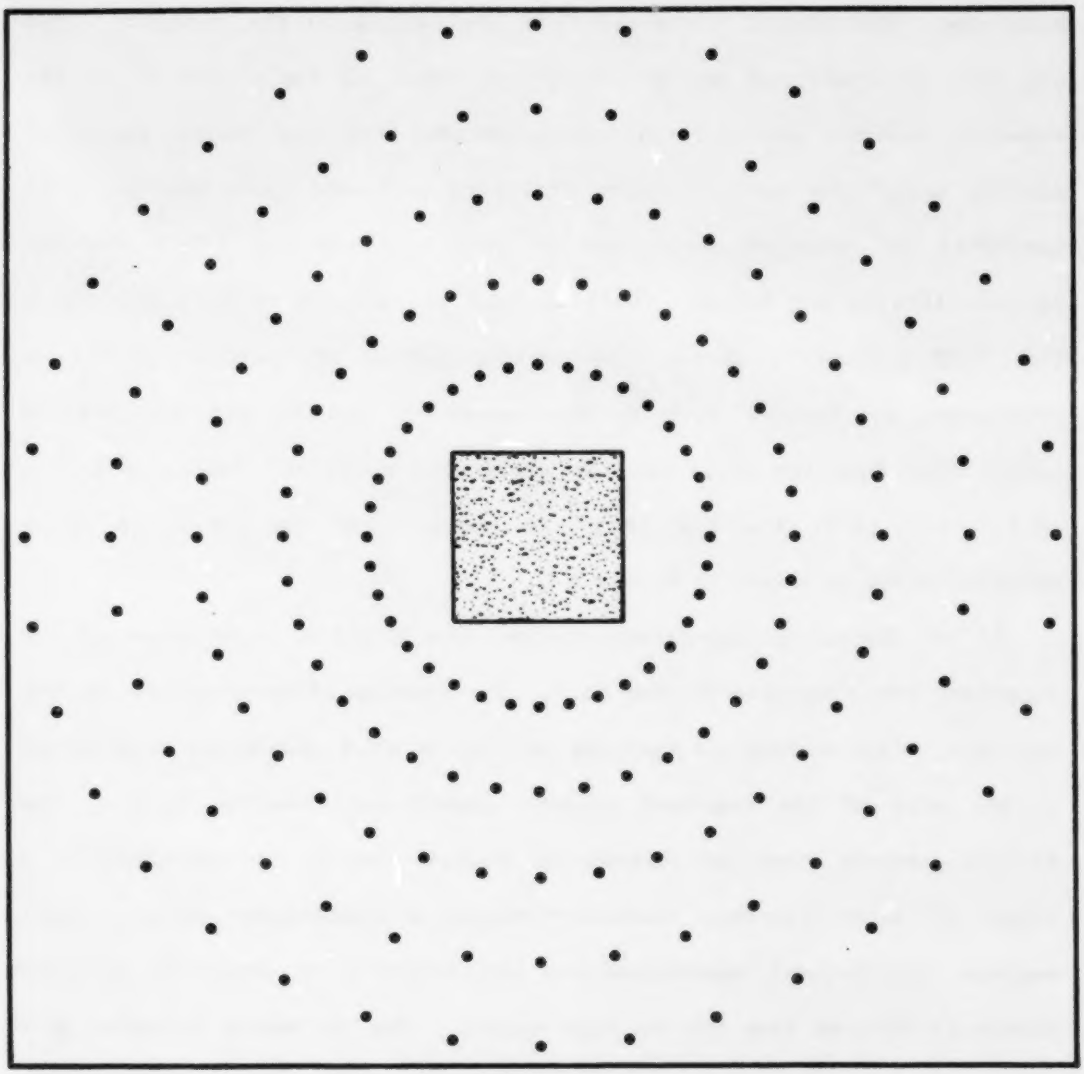


FIGURE 2-2. Example of a polar receptor grid. The stippled area shows the property of a hypothetical industrial source complex.

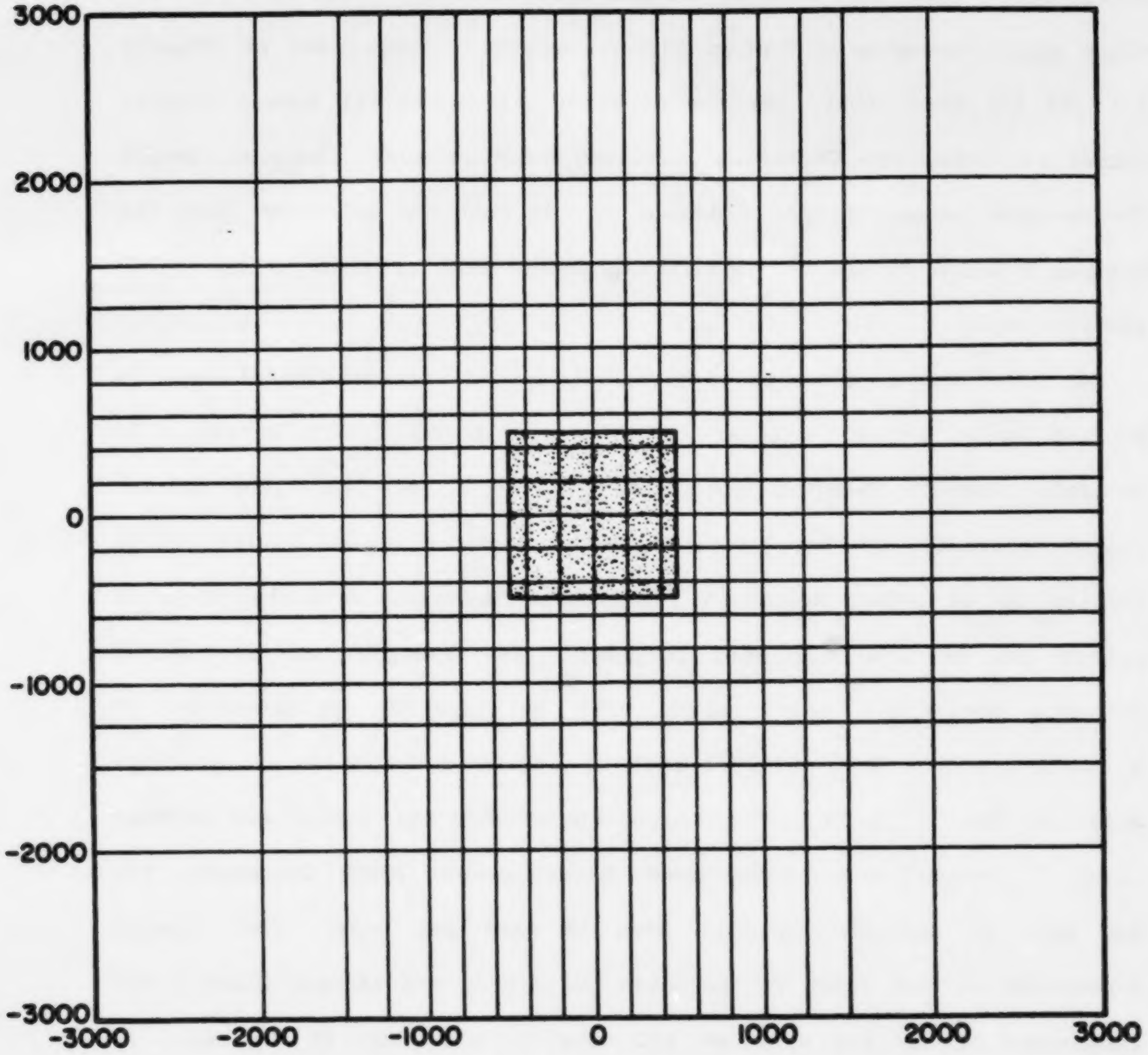

3000
2000
1000
0
-1000
-2000
-3000
-3000
-2000
-1000
0
1000
2000
3000

FIGURE 2-3. Example of an irregularly-spaced Cartesian receptor grid. The stippled area shows the property of a hypothetical industrial source complex.

source, a warning message is printed and concentrations are not calculated for the source-receptor combination. The user should be cautioned, however, that while the dispersion curves have been extrapolated down from 100m to 1m, predicted concentrations at these very close source-receptor distances may be suspect. Comparison of Figures 2-2 and 2-3 shows that, for the hypothetical industrial source complex described above, the Cartesian receptor array is more likely to detect the maximum concentrations produced by the combined emissions from the various sources within the industrial source complex than is the polar receptor array.

As noted above, discrete (arbitrarily spaced) receptor points may be entered using either a polar or a Cartesian coordinate system. In general, discrete receptor points are placed at the locations of air quality monitors, the boundaries of the property of an industrial source complex or at other points of interest. However, discrete receptor points can be used for many purposes. For example, assume that a proposed coal-fired power plant will be located approximately 30 kilometers from a National Park that is a Class I (pristine air quality) area and that it is desired to determine whether the 3-hour and 24-hour Class I Prevention of Significant Deterioration (PSD) Increments for SO_2 will be exceeded on more than 18 days per year. The angular dimensions of the areas within which the 3-hour and 24-hour Class I PSD Increments of SO_2 are exceeded are usually less than 10 degrees. It follows that a polar coordinate system with a 10-degree angular separation of receptors is not adequate to detect all occurrences of 3-hour and 24-hour SO_2 concentrations above the short-term Class I SO_2 Increments. The user may therefore wish to place discrete receptors at 1-degree intervals along the boundary of and within the Class I area.

If model calculations are to be made for an industrial source complex located in terrain exceeding the height of the lowest stack, the elevation above mean sea level of each receptor must be input. If the elevation of any receptor exceeds the height of any stack or the effective emission height of any volume source, the elevation of the receptor is automatically reduced to .005 meters below the stack height (emission height for volume source) for each stack. After computation from this source, the elevation is set back to its original value. However, the user is cautioned that concentrations at these receptors may not be valid.

2.3 Plume Rise Formulas

The Briggs plume rise equations are discussed below. The description follows Appendix B of the Addendum to the MPTER User's Guide (Chico and Catalano, 1986) for plumes unaffected by building wakes. The distance dependent momentum plume rise equations, as described in (Bowers, et al., 1979) are used with building downwash calculations.

2.3.1 Wind Profile

The wind power law is used to adjust the observed wind speed u_1 from the measurement height z_1 (default value of 10 meters) to that at the emission height h. The equation is of the form:

$$u = u_1 (h/z_1)^p \qquad (2\text{-}1)$$

where p is the wind profile exponent. Values may be provided by the user. Default values are given in Table 2-2.

2.3.2 Stack-tip Downwash

In order to consider stack-tip downwash, modification of the physical stack height is performed (as a user option) following Briggs (1974, p. 4).

The modified physical stack height h' is found from:

$$h' = h + 2d\,[(v_s/u) - 1.5] \quad \text{for } v_s < 1.5\,u \qquad (2\text{-}2)$$

or

$$h' = h \quad \text{for } v_s \geq 1.5\,u$$

where h is physical stack height, v_s is stack gas velocity, m s^{-1}, and d is inside stack top diameter, m. This h' is used throughout the remainder of the plume height computation. If stack downwash is not considered, h' = h in the following equations.

2.3.3 Buoyancy Flux

For most plume rise situations, the value of the Briggs buoyancy flux parameter, F, in $m^4\ s^{-3}$ is needed. The following equation is equivalent to equation (12), (Briggs, 1975, p. 63):

$$F = g v_s\, d^2 \Delta T / 4T_s \qquad (2\text{-}3)$$

where $\Delta T = T_s - T_a$, T_s is stack gas temperature (K), and T_a is ambient air temperature (K).

2.3.4 Unstable or Neutral --- Crossover Between Momentum and Buoyancy

For cases with stack gas temperature greater than ambient air temperature, whether the plume rise is dominated by momentum or buoyancy must be determined. The crossover temperature difference $(\Delta T)_c$ is determined for (1) F less than 55 and (2) F greater than or equal to 55. If the difference between stack gas temperature and ambient air temperature, ΔT, exceeds the $(\Delta T)_c$, the buoyant plume rise equation is used; if less than this amount, the momentum plume rise equation is used (see below).

For F less than 55, the crossover temperature difference is found by setting Equation (5.2) (Briggs, 1969, p. 59) equal to the combination of Equations (6) and (7) (Briggs, 1971, p. 1031) and solving for ΔT. The result is:

$$(\Delta T)_c = 0.0297\ T_s\ v_s^{1/3}/d^{2/3} \tag{2-4}$$

For F equal to or greater than 55, the crossover temperature difference is found by setting Equation (5.2) (Briggs, 1969, p. 59) equal to the combination of Equation (6) and (7) (Briggs, 1971, p. 1031) and solving for ΔT. The result is:

$$(\Delta T)_c = 0.00575\ T_s\ v_s^{2/3}/d^{1/3} \tag{2-5}$$

2.3.5 Unstable or Neutral ---- Buoyancy Rise

For situations where ΔT exceeds $(\Delta T)_c$ as determined above, buoyancy is assumed to dominate. The distance to final rise x_f in kilometers, is determined from the equivalent of Equation (7), (Briggs, 1971, p. 1031), and the distance to final rise is assumed to be 3.5 x^*, where x^* is the distance at which atmospheric turbulence begins to dominate entrainment.

For F less than 55:

$$x_f = 0.049\ F^{5/8} \tag{2-6}$$

For F equal to or greater than 55:

$$x_f = 0.119\ F^{2/5} \tag{2-7}$$

The plume height, H, in meters, is determined from the equivalent of the combination of Equations (6) and (7) (Briggs, 1971, p. 1031):

For F less than 55:

$$H = h' + 21.425\ F^{3/4}/u \tag{2-8}$$

For F equal to or greater than 55:

$$H = h' + 38.71\ F^{3/5}/u \qquad (2\text{-}9)$$

2.3.6 Unstable or Neutral ---- Momentum Rise

For situations where the stack gas temperature is less than or equal to the ambient air temperature, the assumption is made that the plume rise is dominated by momentum. If ΔT is less than $(\Delta T)_c$ from Equation (2-4) or (2-5), the assumption is also made that the plume rise is dominated by momentum. The plume height is calculated from Equation (5.2) (Briggs, 1969, p. 59):

$$H = h' + 3d\ v_s/u \qquad (2\text{-}10)$$

Briggs (1969, p. 59) suggests that this equation is most applicable when v_s/u is greater than 4. Since momentum rise occurs quite close to the point of release, the distance to final rise is set equal to zero.

2.3.7 Stability Parameter

For stable situations the stability parameter s is calculated from the equation (Briggs, 1971, p. 1031):

$$s = g(\partial\theta/\partial z)/T_a \qquad (2\text{-}11)$$

As a default approximation, for stability class E, or 5, $\partial\theta/\partial z$ is taken as 0.02 K m^{-1}, and for stability class F, or 6, $\partial\theta/\partial z$ is taken as 0.035 K m^{-1}.

2.3.8 Stable ---- Crossover Between Momentum and Buoyancy

For cases with stack gas temperatures greater than ambient air temperature, determining whether the plume rise is dominated by momentum or buoyancy is necessary. The crossover temperature difference $(\Delta T)_c$ is found by setting Equation (59) (Briggs, 1975, p. 96) equal to Equation (4.28), (Briggs, 1969, p. 59) and solving for ΔT. The result is:

$$(\Delta T)_c = 0.01958\ T_a\ v_s\ s^{1/2} \qquad (2\text{-}12)$$

If the difference between stack gas temperature and ambient air temperature, ΔT, exceeds $(\Delta T)_c$, the plume rise is assumed to be buoyancy dominated; if less than this amount, the plume rise is assumed to be momentum dominated.

2.3.9 Stable ---- Buoyancy Rise

For situations where ΔT exceeds $(\Delta T)_c$ as determined above, buoyancy is assumed to dominate. The distance to final rise, in kilometers, is determined by the equivalent of a combination of Equations (48) and (59) in Briggs, (1975), p. 96):

$$x_f = 0.00207\ u\ s^{-1/2} \qquad (2\text{-}13)$$

The plume height is determined by the equivalent of Equation (59) (Briggs, 1975, p. 96):

$$H = h' + 2.6\ (F/us)^{1/3}$$

2.3.10 Stable ---- Momentum Rise

Where the stack gas temperature is less than or equal to the ambient air temperature, the assumption is made that the plume rise is dominated by momentum. If ΔT is less than $(\Delta T)_c$ as determined by (2-12), the assumption is also made that the plume rise is dominated by momentum. The plume height is calculated from Equation (4.28) of Briggs ((1969), p. 59):

$$H = h' + 1.5[v_s^2 d^2 T_a/(4T_s u)]^{1/3} s^{-1/6} \qquad (2\text{-}15)$$

The equation for unstable-neutral momentum rise (2-10) is also evaluated. The lower result of these two equations is used as the resulting plume height.

2.3.11 All Conditions -- Distance Less Than Distance to Final Rise - (Gradual Rise)

Where gradual rise is to be estimated for unstable, neutral, or stable conditions, if the distance upwind from receptor to source x, in kilometers, is less than the distance to final rise, the equivalent of Equation (2) (Briggs, 1972, p. 1030) is used to determine plume height:

$$H = h' + (160\ F^{1/3} x^{2/3})/u \tag{2-16}$$

This height will be used only for buoyancy dominated conditions; should it exceed the final rise for the appropriate condition, the final rise is substituted instead.

Note that the building downwash algorithm always requires the calculation of a distance dependent momentum plume rise. When building downwash is being simulated, the following equations (Bowers, et al, 1979) are used to calculate a distance dependent momentum plume rise:

a) unstable conditions

$$H = h' + [3\ F_m\ x\ /\ (\beta_j^2\ u^2)]^{1/3} \tag{2-17}$$

where x is the downwind distance (meters), with a maximum value defined by x_{max} as follows:

$$x_{max} = 4d\ (v_s + 3\ u)^2\ /\ (v_s\ u) \quad \text{for } F = 0$$

or

$$58\ F^{5/8} \quad \text{for } 0 < F \leq 55\ m^4/s^3$$

or

$$119\ F^{2/5} \quad \text{for } F > 55\ m^4/s^3$$

b) stable conditions

$$H = h' + [3\ F_m \sin(s^{1/2}\ x\ /\ u)/(\beta_j^2\ u\ s^{1/2})]^{1/3} \tag{2-18}$$

where x is the downwind distance (meters), with a maximum value defined by x_{max} as follows:

$$x_{max} = 0.5\ \pi\ u\ /\ s^{1/2} \qquad \text{for } F = 0$$

or

$$\pi\ u\ /\ s^{1/2} \qquad \text{for } F > 0$$

where $\beta_j = (1/3 + u/v_s)$

$F_m = T_a\ v_s^{\ 2}\ d^2\ /\ (4\ T_s)$

2.4 The ISC Short-Term Dispersion Model Equations

2.4.1 Stack Emissions

The ISC short-term concentration model for stacks uses the steady-state Gaussian plume equation for a continuous elevated source. For each stack and each hour, the origin of the stack's coordinate system is placed at the ground surface at the base of the stack. The x axis is positive in the downwind direction, the y axis is crosswind (normal) to the x axis and the z axis extends vertically. The fixed receptor locations are converted to each stack's coordinate system for each hourly concentration calculation. The hourly concentrations calculated for each stack at each receptor are summed to obtain the total concentration produced at each receptor by the combined stack emissions.

The hourly ground-level concentration at downwind distance x (meters) and crosswind distance y (meters) is given by:

$$X = KQDV\ (\pi u\ \sigma_y\ \sigma_z)^{-1}\ \exp\ [-0.5\ (y/\sigma_y)^2] \tag{2-19}$$

where:

Q = pollutant emission rate (mass per unit time)

K = a scaling coefficient to convert calculated concentrations to desired units (default value of 1×10^6 for Q in g/sec and concentration in µg/m^3)

V = Vertical term (See Equation (2-42))

D = Decay term (See Equation (2-20))

σ_y, σ_z = standard deviation of lateral, vertical concentration distribution (m)

u = mean wind speed (m/sec) at stack height

Equation (2-19) includes a Vertical Term, a Decay Term, and dispersion coefficients (σ_y and σ_z) as discussed below. It should be noted that the Vertical Term includes the effects of source elevation, plume rise, limited mixing in the vertical, and the gravitational settling and dry deposition of larger particulates (particulates with diameters greater than about 20 micrometers).

The Decay Term, which is a simple method of accounting for pollutant removal by physical or chemical processes, is of the form:

$$\begin{aligned} D &= \exp(-\psi\, x/u) \quad \text{for } \psi = 0. \\ &\quad \text{or} \\ &= 0. \qquad\qquad\quad \text{for } \psi = 0. \text{ (i.e., decay not considered when zero is input for } \psi\text{).} \end{aligned} \tag{2-20}$$

where:

ψ = the decay coefficient (sec^{-1})
x = downwind distance (meters)

For example, if $T_{1/2}$ is the pollutant half life in seconds, the user can obtain ψ from the relationship:

$$\psi = 0.693/T_{1/2} \tag{2-21}$$

The default value for ψ is zero. That is, decay is not considered in the model calculations unless ψ is specified. However, a decay half life of 4 hours ($\psi = 0.0000481\text{s}^{-1}$) is automatically assigned for SO_2 modeled in an urban mode when the regulatory default option is chosen.

In addition to stack emissions, the ISC short-term concentration model considers emissions from area and volume sources. The volume-source option is also used to simulate line sources. These model options are described in Section 2.4.2. Section 2.4.3 gives the optional algorithms for calculating dry deposition for stack, area, and volume sources.

2.4.1.1 The Dispersion Coefficients

a. Point Source Dispersion Coefficients. Equations that approximately fit the Pasquill-Gifford curves (Turner, 1970) are used to calculate σ_y (meters) and σ_z (meters) for urban modes 1 and 2 and the rural mode. The equations used to calculate σ_y are of the form:

$$\sigma_y = 465.11628 \ (x) \tan(TH) \tag{2-22}$$

where:

$$TH = 0.017453293 \ (c - d \ln x) \tag{2-23}$$

In Equations (2-22) and (2-23) the downwind distance x is in kilometers, and the coefficients c and d are listed in Table 2-7. The equation used to calculate σ_z is of the form:

$$\sigma_z = ax^b \tag{2-24}$$

where the downwind distance x is in kilometers and σ_z is in meters in Equation (2-24) and the coefficients a and b are given in Table 2-8.

Tables 2-9 and 2-10 show the equations used to determine σ_y and σ_z for Urban Mode 3. These expressions were determined by Briggs as reported by Gifford (1976) and represent a best fit to urban vertical diffusion data reported by McElroy and Pooler (1968). The Briggs functions are assumed to be valid for downwind distances less than 100m. However, the user is cautioned that concentrations at receptors less than 100m from a source may be suspect.

b. Downwind and Crosswind Distances. As noted in Section 2.2.3, the ISC Model uses either a polar or a Cartesian receptor grid as specified by the

TABLE 2-7

PARAMETERS USED TO CALCULATE PASQUILL-GIFFORD σ_y

Pasquill Stability Category	σ_y (meters) = 465.11628 (x) tan (TH) TH = 0.017453293 (c − d ln x) c	 d
A	24.1670	2.5334
B	18.3330	1.8096
C	12.5000	1.0857
D	8.3330	0.72382
E	6.2500	0.54287
F	4.1667	0.36191

*Where σ_y is in meters and x is in kilometers

TABLE 2-8

PARAMETERS USED TO CALCULATE PASQUILL-GIFFORD σ_z

Pasquill Stability Category	x (km)	σ_z (meters) = $a x^b$	
		a	b
A*	<.10	122.800	0.94470
	0.10 - 0.15	158.080	1.05420
	0.16 - 0.20	170.220	1.09320
	0.21 - 0.25	179.520	1.12620
	0.26 - 0.30	217.410	1.26440
	0.31 - 0.40	258.890	1.40940
	0.41 - 0.50	346.750	1.72830
	0.51 - 3.11	453.850	2.11660
	>3.11	**	**
B*	< .20	90.673	0.93198
	0.21 - 0.40	98.483	0.98332
	>0.40	109.300	1.09710
C*	All	61.141	0.91465
D	<.30	34.459	0.86974
	0.31 - 1.00	32.093	0.81066
	1.01 - 3.00	32.093	0.64403
	3.01 - 10.00	33.504	0.60486
	10.01 - 30.00	36.650	0.56589
	>30.00	44.053	0.51179

*If the calculated value of σ_z exceeds 5000 m, σ_z is set to 5000 m.

**σ_z is equal to 5000 m.

TABLE 2-8
(CONTINUED)

PARAMETERS USED TO CALCULATE PASQUILL-GIFFORD σ_z

Pasquill Stability Category	x (km)	σ_z (meters) = $a x^b$ a	b
E	<.10	24.260	0.83660
	0.10 - 0.30	23.331	0.81956
	0.31 - 1.00	21.628	0.75660
	1.01 - 2.00	21.628	0.63077
	2.01 - 4.00	22.534	0.57154
	4.01 - 10.00	24.703	0.50527
	10.01 - 20.00	26.970	0.46713
	20.01 - 40.00	35.420	0.37615
	>40.00	47.618	0.29592
F	<.20	15.209	0.81558
	0.21 - 0.70	14.457	0.78407
	0.71 - 1.00	13.953	0.68465
	1.01 - 2.00	13.953	0.63227
	2.01 - 3.00	14.823	0.54503
	3.01 - 7.00	16.187	0.46490
	7.01 - 15.00	17.836	0.41507
	15.01 - 30.00	22.651	0.32681
	30.01 - 60.00	27.074	0.27436
	>60.00	34.219	0.21716

TABLE 2-9

BRIGGS FORMULAS USED TO CALCULATE McELROY-POOLER σ_y

Pasquill Stability Category	σ_y (meters)*
A	$0.32\ x\ (1.0 + 0.0004\ x)^{-1/2}$
B	$0.32\ x\ (1.0 + 0.0004\ x)^{-1/2}$
C	$0.22\ x\ (1.0 + 0.0004\ x)^{-1/2}$
D	$0.16\ x\ (1.0 + 0.0004\ x)^{-1/2}$
E	$0.11\ x\ (1.0 + 0.0004\ x)^{-1/2}$
F	$0.11\ x\ (1.0 + 0.0004\ x)^{-1/2}$

*Where x is in meters.

TABLE 2-10

BRIGGS FORMULAS USED TO CALCULATE McELROY-POOLER σ_z

Pasquill Stability Category	σ_z (meters)*
A	$0.24\ x\ (1.0 + 0.001\ x)^{1/2}$
B	$0.24\ x\ (1.0 + 0.001\ x)^{1/2}$
C	$0.20\ x$
D	$0.14\ x\ (1.0 + 0.0003\ x)^{-1/2}$
E	$0.08\ x\ (1.0 + 0.0015\ x)^{-1/2}$
F	$0.08\ x\ (1.0 + 0.0015\ x)^{-1/2}$

*Where x is in meters.

user. In the polar coordinate system, the radial coordinate of the point (r, θ) is measured from the user-specified origin and angular coordinate θ is measured clockwise from north. In the Cartesian coordinate system, the X axis is positive to the east of the user-specified origin and the Y axis is positive to the north. For either type of receptor grid, the user must define the location of each source with respect to the origin of the grid using Cartesian coordinates. In the polar coordinate system, where the origin is always at X=0, Y=0, the X and Y coordinates of a receptor at the point (r, θ) are given by:

$$X(R) = r \sin \theta \qquad (2\text{-}25)$$

$$Y(R) = r \cos \theta \qquad (2\text{-}26)$$

If the X and Y coordinates of the source are X(S) and Y(S), the downwind distance x to the receptor is given by:

$$x = -(X(R) - X(S)) \sin DD - (Y(R) - Y(S)) \cos DD \qquad (2\text{-}27)$$

where DD is the direction from which the wind is blowing. If any receptor is located within 1 meter of a source, a warning message is printed and no concentrations are calculated for the source-receptor combination. The crosswind distance y to the receptor (see Equation (2-19)) is given by:

$$y = -(Y(R) - Y(S)) \sin DD - (X(R) - X(S)) \cos DD \qquad (2\text{-}28)$$

c. Lateral and Vertical Virtual Distances. The equations in Tables (2-7) through (2-10) define the dispersion coefficients for an ideal point source. However, volume sources have initial lateral and vertical dimensions. Also, as discussed below, building wake effects can enhance the initial growth of stack plumes. In these cases, lateral (x_y) and vertical (x_z) virtual distances are added by the ISC Model to the actual downwind distance x for the σ_y and σ_z calculations. The lateral virtual distance in kilometers for Urban Mode 1, Urban Mode 2, and the Rural Mode is given by:

$$x_y = (\sigma_{yo}/p)^{1/q} \qquad (2\text{-}29)$$

where the stability-dependent coefficients p and q are given in Table 2-11 and σ_{yo} is the standard deviation in meters of the lateral concentration distribution at the source. Similarly, the vertical virtual distance in kilometers for Urban Mode 1, Urban Mode 2 and the Rural mode is given by:

$$x_z = (\sigma_{zo}/a)^{1/b} \qquad (2\text{-}30)$$

where the coefficients a and b are obtained from Table 2-8 and σ_{zo} is the standard deviation in meters of the vertical concentration distribution at the source. It is important to note that the ISC Model programs check to ensure that the x_z used to calculate σ_z at $(x + x_z)$ in Urban Mode 1, Urban Mode 2, and the Rural Mode is the x_z calculated using the coefficients a and b that correspond to the distance category specified by the quantity $(x + x_z)$.

To determine the virtual distances when Urban Mode 3 is chosen, the functions displayed in Tables 2-9 and 2-10 are solved for x. The solutions are quadratic formulas for the lateral virtual distances; and for vertical virtual distances the solutions are cubic equations for stability classes A and B, a linear equation for stability class C, and quadratic equations for stability classes D, E, and F.

d. Procedures Used to Account for the Effects of Building Wakes on Effluent Dispersion. The procedures used by the ISC Model to account for the

TABLE 2-11

COEFFICIENTS USED TO CALCULATE LATERAL VIRTUAL DISTANCES FOR PASQUILL-GIFFORD DISPERSION RATES

Pasquill Stability Category	$x_y = (\sigma_{yo}/p)^{1/q}$	
	p	q
A	209.14	0.890
B	154.46	0.902
C	103.26	0.917
D	68.26	0.919
E	51.06	0.921
F	33.92	0.919

effects of the aerodynamic wakes and eddies produced by plant buildings and structures on plume dispersion follow the suggestions of Huber and Snyder (1976) and Huber (1977). Their suggestions are principally based on the results of wind-tunnel experiments using a model building with a crosswind dimension double that of the building height. The atmospheric turbulence simulated in the wind-tunnel experiments was intermediate between the turbulence intensity associated with the slightly unstable Pasquill C category and the turbulence intensity associated with the neutral D category. Thus, the data reported by Huber and Snyder reflect a specific stability, building shape and building orientation with respect to the mean wind direction. It follows that the ISC Model wake-effects evaluation procedures may not be strictly applicable to all situations. However, the suggestions of Huber and Snyder are based on the best available data and are used by the ISC Model as interim procedures until additional data become available.

The wake-effects evaluation procedures may be applied by the user to any stack on or adjacent to a building. The first step in the wake-effects evaluation procedures used by the ISC Model programs is to calculate the plume rise due to momentum alone at a distance of two building heights using Equation (2-17) or Equation (2-18). If the plume height, given by the sum of the stack height (no stack-tip downwash adjustment) and the momentum rise is greater than either 2.5 building heights (2.5 h_b) or the sum of the building height and 1.5 times the building width (h_b + 1.5 h_w), the plume is assumed to be unaffected by the building wake. Otherwise, the plume is assumed to be affected by the building wake.

When the plume is affected by the building wake, the distance dependent plume rise is used, even if the user selected final plume rise. The larger value from the distance dependent buoyant plume rise (equation 2-16) or the distance dependent momentum plume rise (equation 2-17 or 2-18) is used.

The ISC Model programs account for the effects of building wakes by modifying σ_z for plumes from stacks with plume height to building height ratios greater than 1.2 (but less than 2.5) and by modifying both σ_y and σ_z for plumes with plume height to building height ratios less than or equal to 1.2. The plume height used in the plume height to stack height ratios is the same plume height used to determine if the plume is affected by the building wake. The ISC Model defines buildings as squat ($h_w \geq h_b$) or tall ($h_w < h_b$). The building width h_w is approximated by the diameter of a circle with an area equal to the horizontal area of the building. The ISC Model includes a general procedure for modifying σ_z and σ_y at distances greater than 3 h_b for squat buildings or 3 h_w for tall buildings. The air flow in the building cavity region is both highly turbulent and generally recirculating. The ISC Model is not appropriate for estimating concentrations within such regions. The ISC Model assumption that this recirculating cavity region extends to a downwind distance of 3 h_b for a squat building or 3 h_w for a tall building is most appropriate for a building whose width is not much greater than its height. The ISC Model user is cautioned that, for other types of buildings, receptors located at downwind distances of 3 h_b (squat buildings) or 3 h_w (tall buildings) may be within the recirculating region. Some guidance and techniques for estimating concentrations very near buildings can be found in Barry (1964), Halitsky (1963) and Vincent (1977) and Budney (1977).

The modified σ_z equation for a squat building is given by:

$$\begin{aligned} \sigma_z' &= 0.7h_b + 0.067(x-3h_b) \quad \text{for } 3h_b < x < 10h_b \\ &\text{or} \\ &= \sigma_z \{x + x_z\} \quad \text{for } x \geq 10h_b \end{aligned} \qquad (2\text{-}31)$$

where the building height h_b is in meters. For a tall building, Huber (1977) suggests that the width scale h_w replace h_b in Equation (2-31). The modified σ_z equation for a tall building is then given by:

$$\begin{aligned} \sigma_z' &= 0.7h_w + 0.067(x-3h_w) && \text{for } 3h_w < x < 10h_w \\ &\text{or} \\ &= \sigma_z \{x + x_z\} && \text{for } x \geq 10\ h_w \end{aligned} \tag{2-32}$$

where h_w is in meters. It is important to note that σ_z' is not permitted to be less than the point source value given in Tables 2-8 or 2-10, a condition that may occur with the A and B stability categories.

The vertical virtual distance x_z is added to the actual downwind distance x at downwind distances beyond $10h_b$ (squat buildings) or $10h_w$ (tall buildings) in order to account for the enhanced initial plume growth caused by the building wake. It is calculated from solutions to the equations for rural or urban sigmas provided earlier.

As an example for the rural options, Equations (2-24) and (2-31) can be combined to derive the vertical virtual distance x_z for a squat building. First, it follows from Equation (2-31) that the enhanced σ_z is equal to $1.2h_b$ at a downwind distance of $10h_b$ in meters or $0.01\ h_b$ in kilometers. Thus, x_z for a squat building is obtained from Equation (2-24) as follows:

$$\sigma_z \{0.01\ h_b\} = 1.2h_b = a\ (0.01h_b + x_z)^b \tag{2-33}$$

$$x_z = (1.2h_b/a)^{1/b} - 0.01h_b \tag{2-34}$$

where the stability-dependent constants a and b are given in Table 2-8. Similarly, the vertical virtual distance for tall buildings is given by:

$$x_z = (1.2h_w/a)^{1/b} - 0.01h_w \tag{2-35}$$

When Urban Mode 3 is selected x_z is calculated from solutions to the equations in Table 2-10 for $\sigma_z = 1.2\ h_b$ or $\sigma_z = 1.2\ h_w$ for tall or squat buildings, respectively.

For a squat building with a building width to building height ratio h_w/h_b less than or equal to 5, the modified σ_y equation is given by:

$$\begin{aligned} \sigma_y' &= 0.35h_w + 0.067\ (x - 3h_b) && \text{for } 3h_b < x < 10h_b \\ &\text{or} \\ &= \sigma_y\ \{x + x_y\} && \text{for } x \geq 10h_b \end{aligned} \qquad (2\text{-}36)$$

at a downwind distance of $10h_b$. The lateral virtual distance is then calculated for this value of σ_y.

For building width to building height ratios h_w/h_b greater than 5, the presently available data are insufficient to provide general equations for σ_y. For a building that is much wider than it is tall and a stack located toward the center of the building (i.e., away from either end), only the height scale is considered to be significant. The modified σ_y equation for a very squat building is then given by:

$$\begin{aligned} \sigma_y' &= 0.35h_b + 0.067\ (x - 3h_b) && \text{for } 3h_b < x < 10h_b \\ &\text{or} \\ &= \sigma_y\ \{x + x_y\} && \text{for } x \geq 10h_b \end{aligned} \qquad (2\text{-}37)$$

For h_w/h_b greater than 5 and a stack located laterally within about 2.5 h_b of the end of the building, lateral plume spread is affected by the flow around the end of the building. With end effects, the enhancement in the initial lateral spread is assumed not to exceed that given by Equation (2-36) with h_w replaced by $5h_b$. The modified σ_y equation is given by:

$$\begin{aligned} \sigma_y' &= 1.75h_b + 0.067\ (x - 3h_b) && \text{for } 3h_b < x < 10h_b \\ &\text{or} \\ &= \sigma_y\ \{x + x_y\} && \text{for } x \geq 10h_b \end{aligned} \qquad (2\text{-}38)$$

The upper and lower bounds of the concentrations that can be expected to occur near a building are determined respectively using Equations (2-37) and (2-38). The user must specify whether Equation (2-37) or Equation (2-38) is to be used in the model calculations. In the absence of user instructions, the ISC Model uses Equation (2-37) if the building width to building height ratio h_w/h_b exceeds 5.

Although Equation (2-37) provides the highest concentration estimates for squat buildings with building width to building height ratios h_w/h_b greater than 5, the equation is applicable only to a stack located near the center of the building when the wind direction is perpendicular to the long side of the building (i.e., when the air flow over the portion of the building containing the source is two dimensional). Thus, Equation (2-38) generally is more appropriate than Equation (2-37). It is believed that Equations (2-37) and (2-38) provide reasonable limits on the extent of the lateral enhancement of dispersion and that these equations are adequate until additional data are available to evaluate the flow near very wide buildings.

The modified σ_y equation for a tall building is given by:

$$\begin{aligned} \sigma_y &= 0.35h_w + 0.067(x - 3h_w) \quad \text{for } 3h_w < x < 10h_w \\ &\text{or} \\ &= \sigma_y \{x + x_y\} \quad \text{for } x \geq 10h_w \end{aligned} \qquad (2\text{-}39)$$

The ISC Model programs print a warning message and do not calculate concentrations for any source-receptor combination where the source-receptor separation is less than 1 meter or $3h_b$ for a squat building or $3h_w$ for a tall building. It should be noted that, for certain combinations of stability and building height and/or width, the vertical and/or lateral plume dimensions indicated for a point source by the dispersion curves at a downwind distance of ten building heights or widths can exceed the values given by Equation (2-31) or (2-32) and by Equation (2-36), (2-37). Consequently, the ISC Model programs do not permit the virtual distances x_y and x_z to be less than zero.

It is important to note that the use of a single effective building width h_w for all wind directions is a simplification that is required to enable the ISC Model computer programs to operate within the constraints imposed on the programs without sacrificing other desired ISC Model features. The effective building width h_w affects σ_z for tall buildings ($h_w < h_b$) and σ_y for squat buildings ($h_w \geq h_b$) with plume height to building height ratios less than or equal to 1.2. Tall buildings typically have lengths and widths that are equivalent so that the use of one value of h_w for all wind directions does not significantly affect the accuracy of the calculations. However, the use of one value of h_w for squat buildings with plume height to building height ratios less than or equal to 1.2 affects the accuracy of the calculations near the source if the building length is large in comparison with the building width. For example, if the building height and width are approximately the same and the building length is equal to five building widths, the ISC Model at a downwind distance of $10h_b$ underestimates the centerline concentration or deposition by about 40 percent for winds parallel to the building's long side and overestimates the centerline concentration (or deposition) by about 60 percent for winds normal to the building's long side. Thus, the user should exercise caution in interpreting the results of concentration (or deposition) calculations for receptors located near a squat building if the stack height to building height ratio is less than or equal to 1.2.

The recommended procedure for calculating accurate concentration (or deposition) values for receptors located near squat buildings consists of two phases. First, the appropriate ISC Model program is executed using the effective building width h_w derived from the building length and width.

Second, the ISC Model calculations are repeated for the receptors near the source with highest calculated concentration (or deposition) values using receptor-specific values of h_w. For example, assume that the ISCST program is used with a year of sequential hourly data to calculate maximum 24-hour average concentrations and that the highest calculated concentrations occur at Receptor A on Julian Day 18 and at Receptor B on Julian Day 352. The crosswind building width h_w associated with the wind directions required to transport emissions to Receptors A and B may be obtained from a scale drawing of the building. The ISCST program is then executed for Receptor A only on Day 18 only using the appropriate h_w value for Receptor A. Similarly, the ISCST program is executed for Receptor B only on Day 352 only using the appropriate h_w value for Receptor B.

e) Procedures Used to Account for Buoyancy-Induced Dispersion

The method of Pasquill (1976) is a user option to account for the initial dispersion of plumes caused by turbulent motion of the plume and turbulent entrainment of ambient air. With this method the effective vertical dispersion (σ_{ze}) is calculated as follows:

$$\sigma_{ze} = [\sigma_z^2 + (\Delta H/3.5)^2]^{1/2} \qquad (2\text{-}40)$$

where σ_z is the vertical dispersion due to ambient turbulence and ΔH is the plume rise due to momentum and/or buoyancy. The lateral plume spread is parameterized using a similar expression:

$$\sigma_{ye} = [\sigma_y^2 + (\Delta H/3.5)^2]^{1/2} \qquad (2\text{-}41)$$

where σ_y is the lateral dispersion due to ambient turbulence. It should be noted that ΔH is the transitional plume height if the receptor is located between the source and the distance to final rise, and final plume rise if the receptor is located beyond the distance to final rise. Thus, if the user elects to use final plume rise at all receptors the transitional plume rise is used in the calculation of buoyancy-induced dispersion and the final plume rise is used in the concentration equations.

2.4.1.2 The Vertical Term

a. The Vertical Term for Gases and Small Particulates. In general, the effects on ambient concentrations of gravitational settling and dry deposition can be neglected for gaseous pollutants and small particulates (diameters less than about 20 micrometers). The Vertical Term is then given by:

$$V = \exp[-0.5(H/\sigma_z)^2] + \sum_{i=1}^{\infty} \{\exp[-0.5(H_1/\sigma_z)^2] + \exp[-0.5(H_2/\sigma_z)^2]\} \qquad (2\text{-}42)$$

where:

$H = h + \Delta h$

$H_1 = 2iH_m - H$

$H_2 = 2iH_m + H$

H_m = mixing height

The infinite series term in Equation (2-42) accounts for the effects of the restriction on vertical plume growth at the top of the mixing layer. As shown by Figure 2-4, the method of image sources is used to account for multiple reflections of the plume from the ground surface and at the top of the surface mixing layer. It should be noted that, if the effective stack height H exceeds the mixing height H_m, the plume is assumed to remain elevated and the ground-level concentration is set equal to zero.

Equation (2-42) assumes that the mixing height in rural and urban areas is known for all stability categories. As explained below, the meteorological

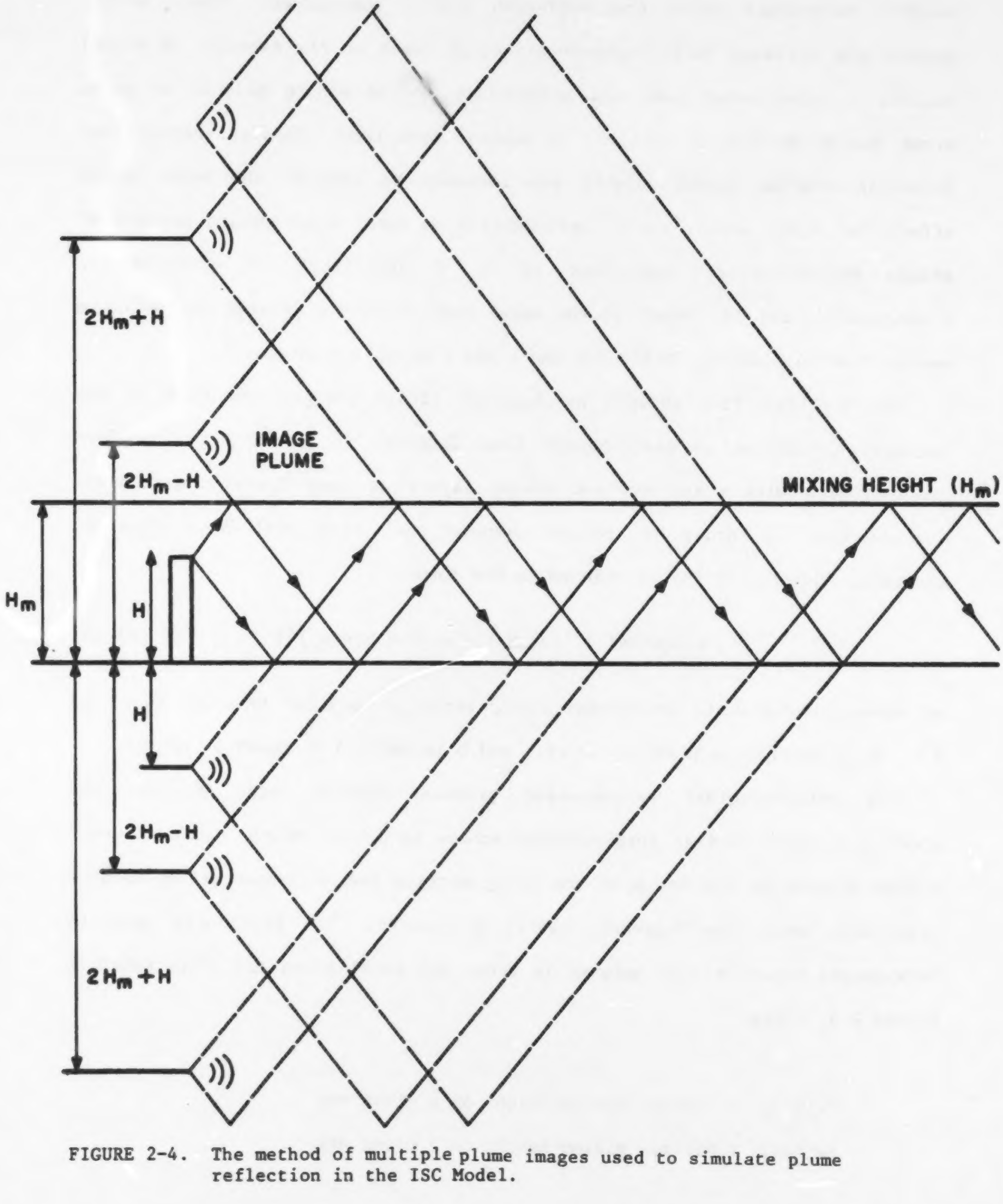

2Hm+H
IMAGE PLUME
2Hm−H
MIXING HEIGHT (Hm)
Hm
H
H
2Hm−H
2Hm+H

FIGURE 2-4. The method of multiple plume images used to simulate plume reflection in the ISC Model.

preprocessor program uses mixing heights derived from twice-daily mixing heights calculated using the Holzworth (1972) procedures. These mixing heights are believed to be representative, at least on the average, of mixing heights in urban areas under all stabilities and of mixing heights in rural areas during periods of unstable or neutral stability. However, because the Holzworth minimum mixing heights are intended to include the heat island effect for urban areas, their applicability to rural areas during periods of stable meteorological conditions (E or F stability) is questionable. Consequently, the ISC Model in the Rural Mode currently deletes the infinite series term in Equation (2-42) for the E and F stability categories.

The Vertical Term defined by Equation (2-42) changes the form of the vertical concentration distribution from Gaussian to rectangular (uniform concentration within the surface mixing layer) at long downwind distances. Consequently, in order to reduce computational time without a loss of accuracy, Equation (2-19) is changed to the form:

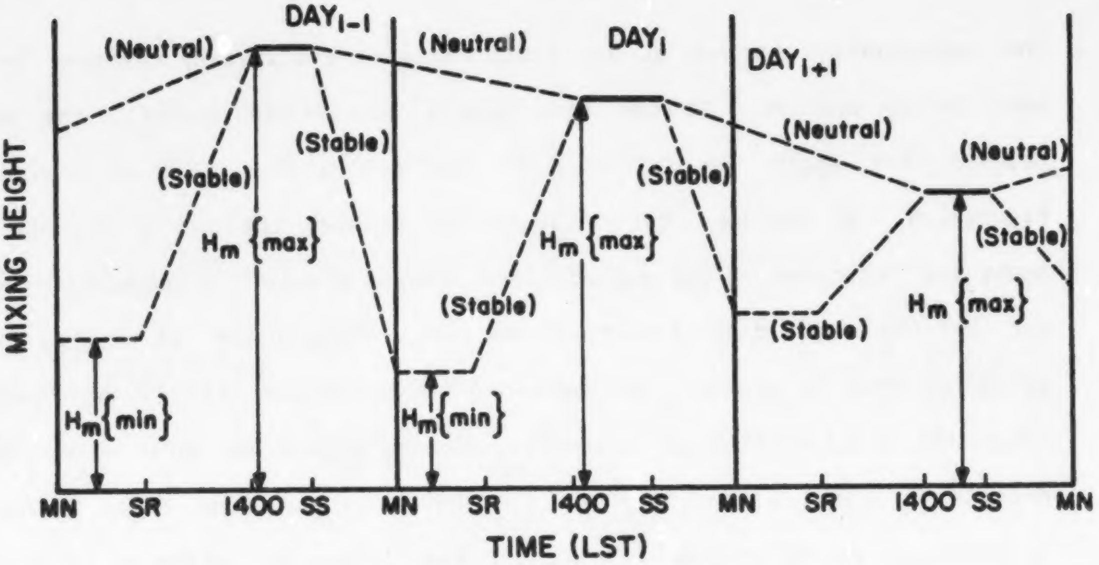
$$\chi = KQD(2\pi)^{-1/2}(u\sigma_y H_m)^{-1} \exp[-0.5(y/\sigma_y)^2] \tag{2-43}$$

at downwind distances where the σ_z/H_m ratio is greater than or equal to 1.6. K is defined in Equation (2-19), and D is defined in Equation (2-20).

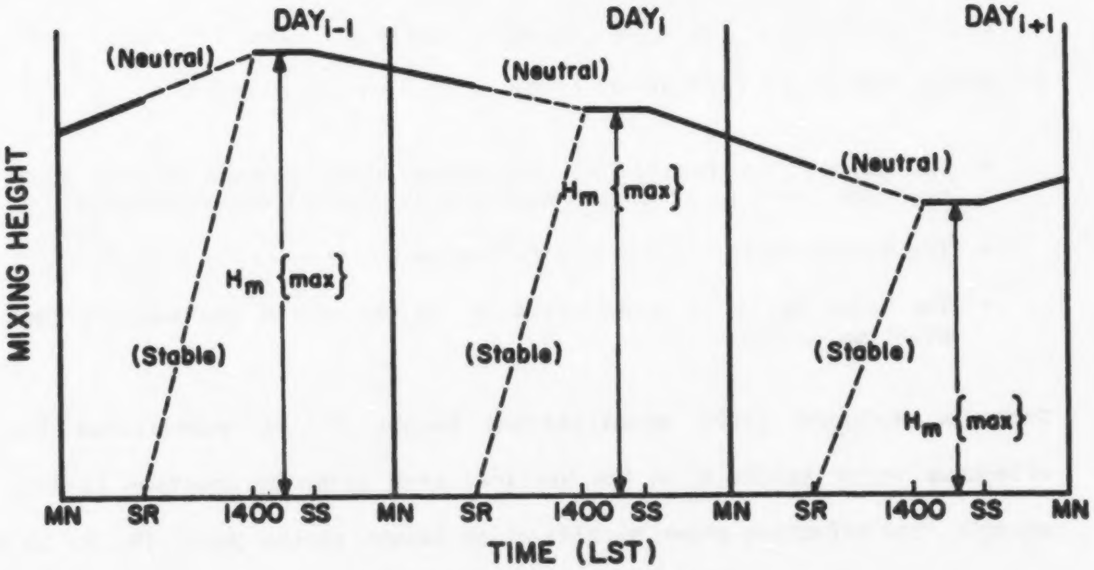
The meteorological preprocessor program, RAMMET, used by the ISC short-term model uses an interpolation scheme to assign hourly rural or urban mixing heights on the basis of the early morning and afternoon mixing heights calculated using the Holzworth (1972) procedures. The procedures used to interpolate hourly mixing heights in urban and rural areas are illustrated in Figure 2-5, where:

$H_m\{max\}$ = maximum mixing height on a given day

$H_m\{min\}$ = minimum mixing height on a given day


DAY$_{i-1}$
DAY$_i$
DAY$_{i+1}$
(Neutral)
(Neutral)
(Neutral)
(Neutral)
(Stable)
(Stable)
(Stable)
(Stable)
(Stable)
(Stable)
H_m {max}
H_m {max}
H_m {max}
H_m {min}
H_m {min}
MIXING HEIGHT
MN
SR
1400
SS
MN
SR
1400
SS
MN
SR
1400
SS
MN
TIME (LST)

(a) Urban Mixing Heights


DAY$_{i-1}$
DAY$_i$
DAY$_{i+1}$
(Neutral)
(Neutral)
(Neutral)
H_m {max}
H_m {max}
H_m {max}
(Stable)
(Stable)
(Stable)
MIXING HEIGHT
MN
SR
1400
SS
MN
SR
1400
SS
MN
SR
1400
SS
MN
TIME (LST)

(b) Rural Mixing Heights

FIGURE 2-5. Schematic illustration of (a) urban and (b) rural mixing height interpolation procedures.

MN = midnight

SR = sunrise

SS = sunset

The interpolation procedures are functions of the stability category for the hour before sunrise. If the hour before sunrise is neutral, the mixing heights that apply are indicated by the dashed lines labeled neutral in Figure 2-5. If the hour before sunset is stable, the mixing heights that apply are indicated by the dashed lines labeled stable. It should be pointed out that there is a discontinuity in the rural mixing height at sunrise if the preceding hour is stable. As explained above, because of the uncertainties about the applicability of Holzworth mixing heights to rural areas during periods of E and F stability, the ISC Model in the Rural Mode ignores the interpolated mixing heights for E and F stabilities and effectively sets the mixing height equal to a very high value.

b. The Vertical Term in Elevated Terrain. The ISC Model makes the following assumption about plume behavior in elevated terrain:

- The plume axis remains at the plume stabilization height above mean sea level as it passes over elevated or depressed terrain.
- The mixing height is terrain following.
- The wind speed is a function of height above the surface (see Equation (2-1)).

Thus, a modified plume stabilization height H' is substituted for the effective stack height H in the Vertical term given by Equation (2-42). For example, the effective plume stabilization height at the point (X, Y) is given by:

$$H' = H + z_s - z \qquad (2\text{-}44)$$

where:

z_s = height above mean sea level of the base of the stack

z = height above mean sea level of the receptor

It should also be noted that, as recommended by EPA, the ISC model now "truncates" terrain at stack height as follows: if the terrain height ($z - z_s$) exceeds stack height, h, for a stack or emission height, H, for a volume source (see Section 2.4.2), the elevation of the receptor is automatically reduced to .005 meters below the stack height (emission height for volume source). The user is cautioned that concentrations at these complex terrain receptors are subject to considerable uncertainty. Figure 2-6 illustrates the terrain-adjustment procedures used by the ISC Model.

c. The Vertical Term for Large Particulates. The dispersion of particulates or droplets with significant gravitational settling velocities differs from that of gaseous pollutants and small particulates in that the larger particulates are brought to the surface by the combined processes of atmospheric turbulence and gravitational settling. Additionally, gaseous pollutants and small particulates tend to be reflected from the surface, while larger particulates that come in contact with the surface may be completely or partially retained at the surface. The ISC Model Vertical Term for large particulates includes the effects of both gravitational settling and dry deposition. Gravitational settling is assumed to result in a tilted plume with the plume axis inclined to the horizontal at an angle give by arctan (V_s/u) where V_s is the gravitational settling velocity. A user-specified fraction γ of the material that reaches the ground surface by the combined processes of gravitational settling and atmospheric turbulence is assumed to be reflected from the surface. Figure 2-7 illustrates the vertical

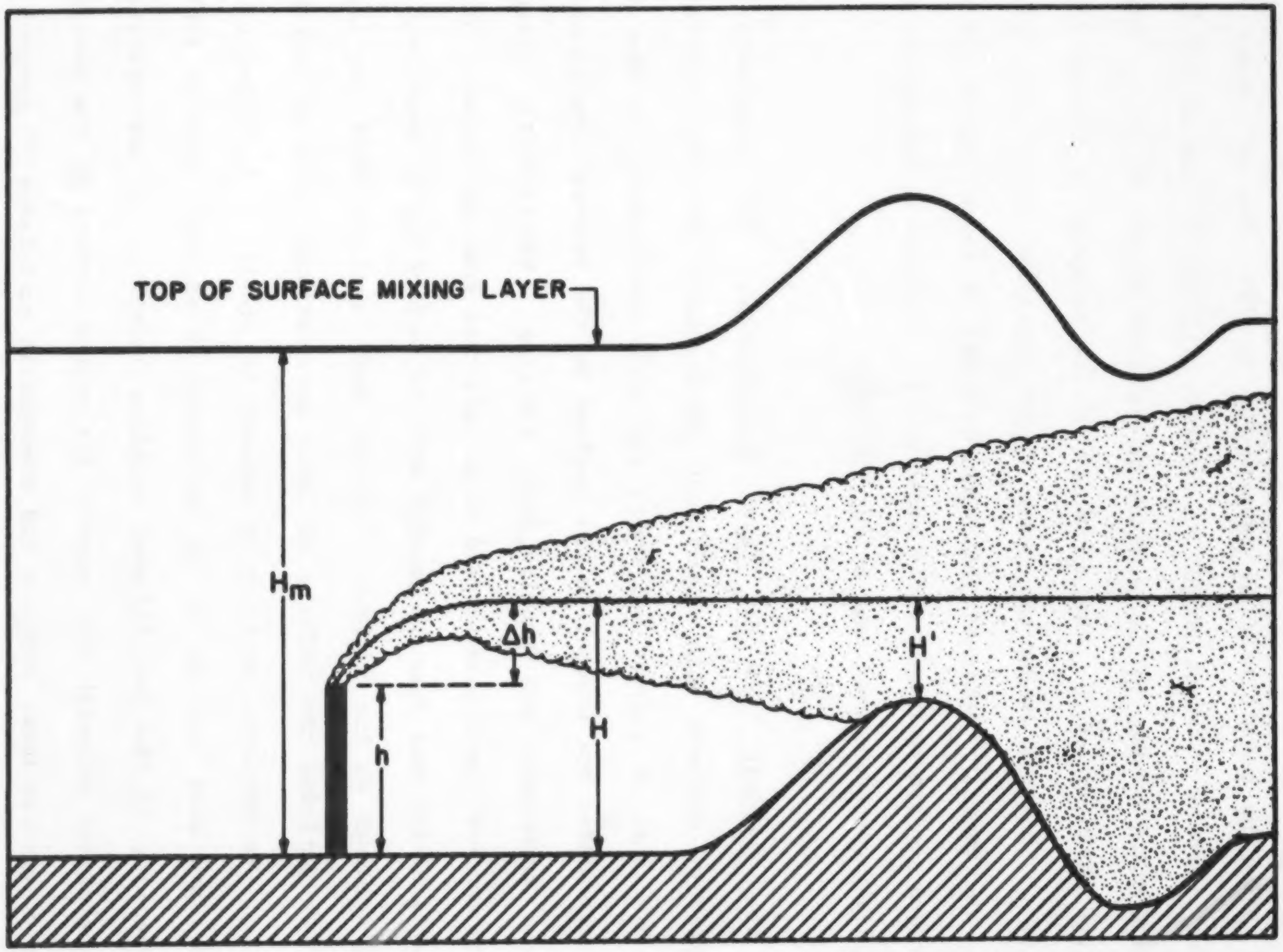

TOP OF SURFACE MIXING LAYER
H_m
Δh
H'
H
h

Figure 2-6. Illustration of plume behavior in complex terrain assumed by the ISC Model.

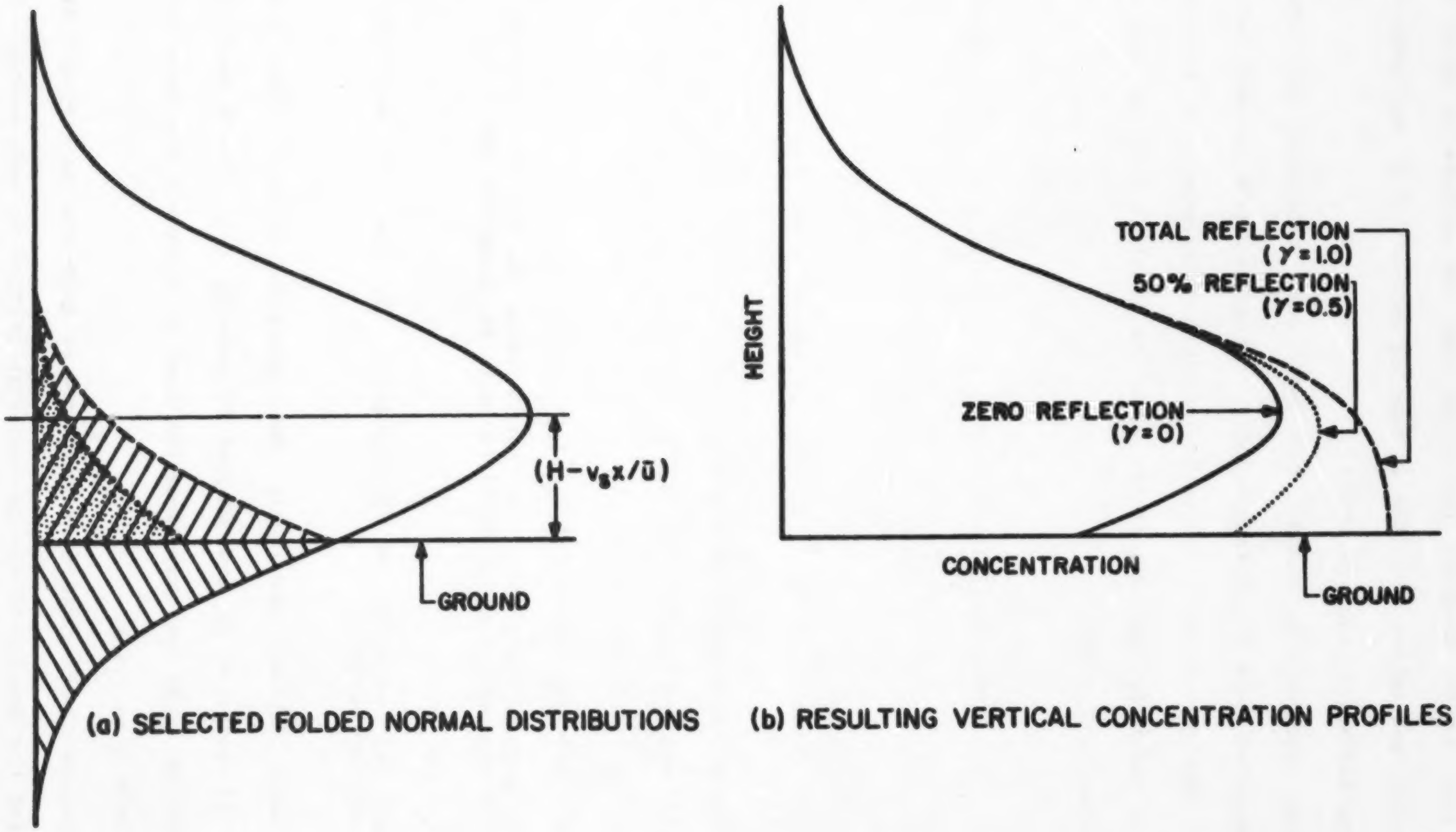

(H−v_g x/ū)
GROUND
(a) SELECTED FOLDED NORMAL DISTRIBUTIONS
HEIGHT
TOTAL REFLECTION (γ=1.0)
50% REFLECTION (γ=0.5)
ZERO REFLECTION (γ=0)
CONCENTRATION
GROUND
(b) RESULTING VERTICAL CONCENTRATION PROFILES

FIGURE 2-7. Illustration of vertical concentration profiles for reflection coefficients of 0, 0.5 and 1.0.

concentration profiles for complete reflection from the surface (γ equal to unity), 50-percent reflection from the surface (γ equal to 0.5) and complete retention at the surface (γ equal to zero).

For a given particulate source, the user must subdivide the total particulate emissions into N settling-velocity categories (the maximum value of N is 20). The ground-level concentration of particulates with settling velocity V_{sn} is given by Equation (2-19) with the Vertical Term defined as (Dumbauld and Bjorklund, 1975):

$$V = 0.5\ \phi_n \left[\sum_{i=0}^{\infty} (A_1 + A_2) + \sum_{i=1}^{\infty} (A_3 + A_4)\right] \tag{2-45}$$

where:

ϕ_n = mass fraction of particulates in the n^th^ settling - velocity category

A_1 = $\gamma_n^i \exp\left[-0.5\left((H_1 + H_v)/\sigma_z\right)^2\right]$

A_2 = $\gamma_n^{i+1} \exp\left[-0.5\left((H_2 - H_v)/\sigma_z\right)^2\right]$

A_3 = $\gamma_n^i \exp\left[-0.5\left((H_2 - H_v)/\sigma_z\right)^2\right]$

A_4 = $\gamma_n^{i-1} \exp\left[-0.5\left((H_1 + H_v)/\sigma_z\right)^2\right]$

γ_n = reflection coefficient for particulates in the n^{th} settling - velocity category (Set equal to unity for complete relection)

H_v = $V_{sn}\, x/u$

V_{sn} = settling velocity of particulates in the n^{th} settling - velocity category

H_1 and H_2 were defined previously for equation (2-42). The total concentration is computed by the program by summing over the N settling-velocity categories. The optional algorithm used to calculate dry deposition is discussed in Section 2.4.3.

Use of Equation (2-45) requires a knowledge of both the particulate size distribution and the density of the particulates emitted by each source. The total particulate emissions for each source are subdivided by the user into a maximum of 20 categories and the gravitational settling velocity is calculated for the mass-mean diameter of each category. The mass-mean diameter is given by:

$$d = [0.25\ (d_2^3 + d_1^2 d_2 + d_1 d_2^2 + d_1^3)]^{1/3} \qquad (2\text{-}46)$$

where d_1 and d_2 are the lower and upper bounds of the particle-size category. McDonald (1960) gives simple techniques for calculating the gravitational settling velocity for all sizes of particulates. For particulates with a density on the order of 1 gram per cubic centimeter and diameters less than about 80 micrometers, the settling velocity is given by:

$$V_s = 2\rho g r^2/9\mu \qquad (2\text{-}47)$$

where:

V_s = settling velocity (cm • sec^{-1})

ρ = particle density (gm • cm^{-3})

g = acceleration due to gravity (980 cm • sec^{-2})

r = particle radius (cm)

μ = absolute viscosity of air ($\mu \sim 1.83 \times 10^{-4}$ gm • cm^{-1} • sec^{-1})

It should be noted that the settling velocity calculated using Equation (2-47) must be converted by the user from centimeters per second to meters per second for use in the model calculations.

The reflection coefficient γ_n can be estimated for each particle-size category using Figure 2-8 and the settling velocity calculated for the mass-mean diameter. If it is desired to include the effects of gravitational settling in calculating ambient particulate concentrations while at the same time excluding the effects of deposition, γ_n should be set equal to unity for all settling velocities. On the other hand, if it is desired to calculate

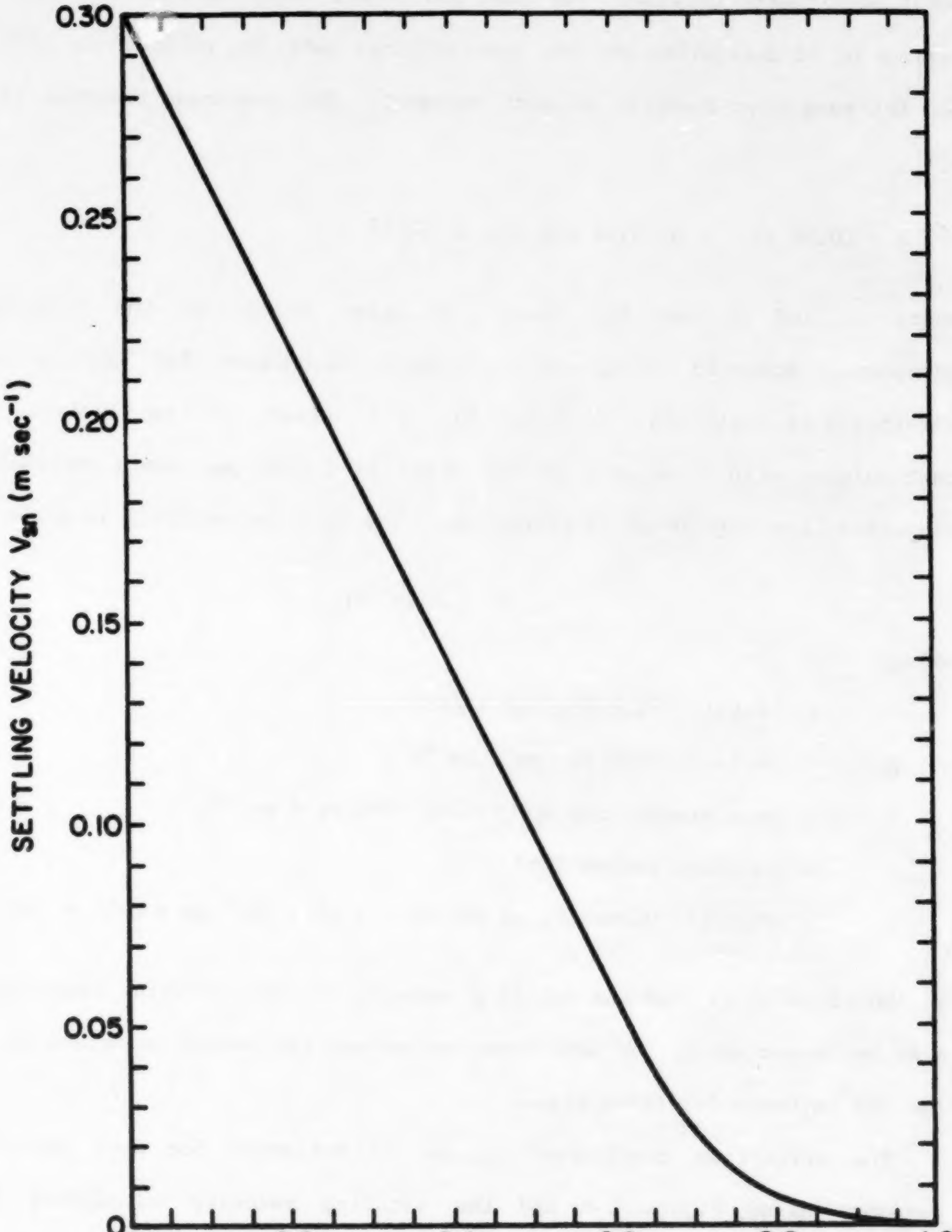


FIGURE 2-8. Relationship between the gravitational settling velocity V_{sn} and the reflection coefficient γ_n suggested by Dumbauld, et al. (1976).

maximum possible deposition, γ_n should be set equal to zero for all settling velocities. The effects of dry deposition for gaseous pollutants may be estimated by setting the settling velocity V_{sn} equal to zero and the reflection coefficient γ_n equal to the amount of material assumed to be reflected from the surface. For example, if 20 percent of a gaseous pollutant that reaches the surface is assumed to be retained at the surface by vegetation uptake or other mechanisms, γ_n is equal to 0.8.

The derivation of Equation (2-45) assumes that the terrain is flat or gently rolling. Consequently, the gravitational settling and dry deposition options cannot be used for sources located in complex terrain without violating mass continuity. However, the effects of gravitational settling alone can be estimated for sources located in complex terrain by setting γ_n equal to unity for each settling velocity category. This procedure will tend to overestimate ground-level concentrations, especially at the longer downwind distances, because it neglects the effects of dry deposition.

It should be noted that Equation (2-45) assumes that σ_z is a continuous function of downwind distance. Also, Equation (2-45) does not simplify for σ_z/H_m greater than 1.6 as does Equation (2-42). As shown by Table 2-8, σ_z for the very unstable A stability category attains a maximum value of 5,000 meters at 3.11 kilometers. Because Equation (2-45) requires that σ_z be a continuous function of distance, the coefficients a and b given in Table 2-8 for A stability and the 0.51- to 3.11-kilometer range are used by the ISC Model in calculations beyond 3.11 kilometers. Consequently, this introduces uncertainties in the results of the calculations beyond 3.11 kilometers for A stability.

2.4.2 Area, Volume and Line Source Emissions

2.4.2.1 General

The area and volume sources options of the ISC Model are used to simulate the effects of emissions from a wide variety of industrial sources. In general, the ISC area source model is used to simulate the effects of fugitive emissions from sources such as storage piles and slag dumps. The ISC volume source model is used to simulate the effects of emissions from sources such as building roof monitors and line sources (for example, conveyor belts and rail lines).

2.4.2.2 The Short-Term Area Source Model

The ISC area source model is based on the equation for a finite crosswind line source. Individual area sources are required to have the same north-south and east-west dimensions. However, as shown by Figure 2-9. the effects of an area source with an irregular shape can be simulated by dividing the area source into multiple squares that approximate the geometry of the area source. Note that the size of the individual area sources in Figure 2-9 varies; the only requirement is that each area source must be square. The ground-level concentration at downwind distance x (measured from the downwind edge of the area source) and crosswind distance y is given by:

$$\chi = K Q_A x_o D V E \, (2\pi)^{-1/2} \, (u\sigma_z)^{-1} \qquad (2\text{-}48)$$

where:

V = vertical term

D = decay term

E = $\mathrm{erf}\,[(0.5\,x'_o + y)(2^{-1/2}\,\sigma_y^{-1})] + \mathrm{erf}\,[(0.5x'_o - y)\,2^{-1/2}\,\sigma_y^{-1}]$

Q_A = area source emission rate (mass per unit area per unit time)

x_o = length of the side of the area source (m)

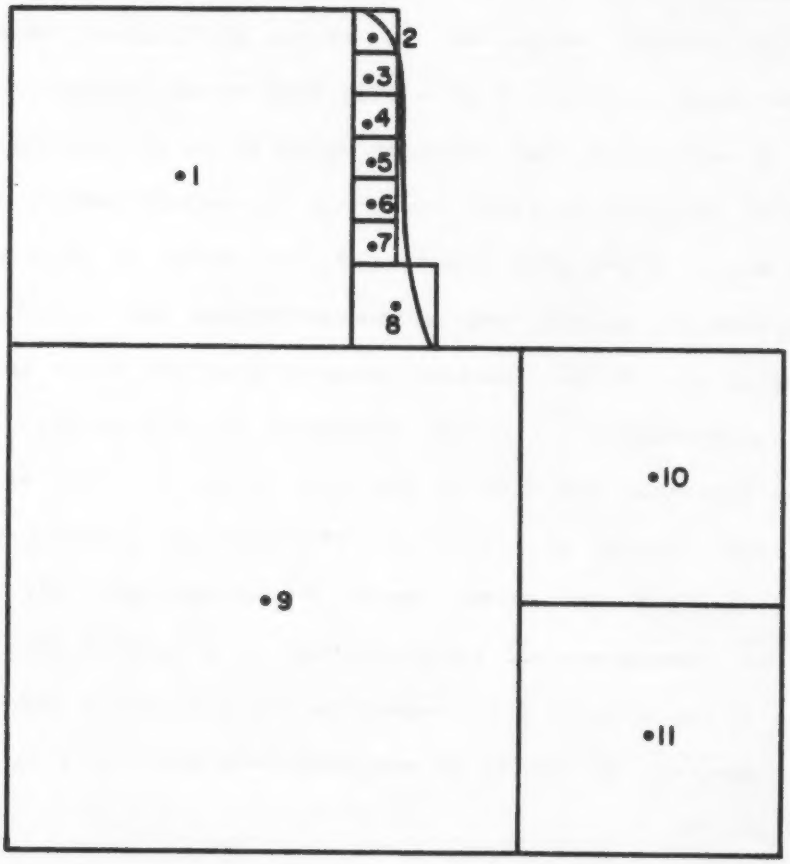

1
2
3
4
5
6
7
8
9
10
11

FIGURE 2-9. Representation of an irregularly shaped area source by 11 square area sources.

x'_o = effective crosswind width = $2x_o(\pi)^{-1/2}$ (m)

K = units scaling coefficient (Equation (2-19))

and the Vertical Term is given by Equation (2-42) or Equation (2-45) with the effective emission height H assigned by the user. In general, H should be set equal to the physical height of the source of fugitive emissions. For example, the emission height H of a slag dump is the physical height of the slag dump. A vertical virtual distance, given by x_o in kilometers, is added to the actual downwind distance x for the σ_z calculations. If a receptor is located within $x'_o/2$ plus 1 meter of the center of an area source, a warning message is printed and no concentrations are calculated for the source-receptor combination. However, program execution is not terminated.

It is recommended that, if the separation between an area source and a receptor is less than the side of the area source x_o, the area source be subdivided into smaller area sources. If the source-receptor separation is less than x_o, the ISC Model tends to overpredict the area source concentration. The degree of overprediction is a function of stability, the orientation of the receptor with respect to the area source and the mean wind direction. However, the degree of overprediction near the area source rarely exceeds 30 percent.

2.4.2.3 The Short-Term Volume Source Model

Equation (2-19) is also used to calculate ground-level concentrations produced by volume-source emissions. If the volume source is elevated, the user assigns the emission height H. The user also assigns initial lateral (σ_{yo}) and vertical (σ_{zo}) dimensions for the volume source. Lateral (x_y) and vertical (x_z) virtual distances are added to the actual downwind distance x for the σ_y and σ_z calculations. The virtual distances are calculated from solutions to the sigma equations as is done for point sources.

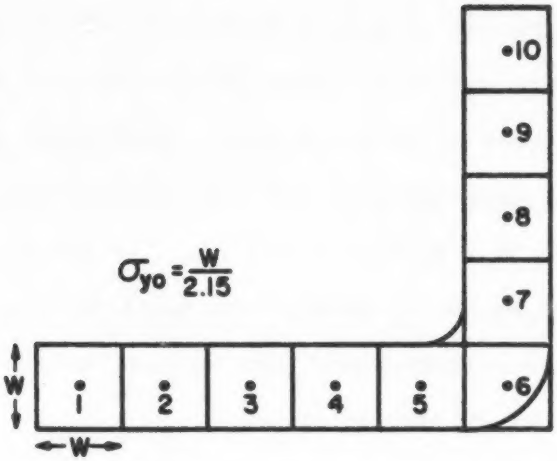
The volume source model is used to simulate the effects of emissions from sources such as building roof monitors and line sources (for example, conveyor belts and rail lines). As with the area source model, the north-south and east-west dimensions of each volume source used in the model must be the same. Table 2-12 summarizes the general procedures suggested for estimating initial lateral (σ_{yo}) and vertical (σ_{zo}) dimensions for single volume sources and for multiple volume sources used to represent a line source. In the case of a long and narrow line source such as a rail line, it may not be practical to divide the source into N volume sources, where N is given by the length of the line source divided by its width. The user can obtain an approximate representation of the line source by placing a smaller number of volume sources at equal intervals along the line source. In general, the spacing between individual volume sources should not be greater than twice the width of the line source. However, a larger spacing can be used if the ratio of the minimum source-receptor separation and the spacing between individual volume sources is greater than about 3. In these cases, concentrations at the nearest receptors may be underestimated by 10 to 15 percent. At longer downwind distances, concentrations calculated using fewer than N volume sources to represent the line source converge to the concentrations calculated using N volume sources to represent the line source as long as sufficient volume sources are used to preserve the horizontal geometry of the line source.

Figure 2-10 illustrates representations of a curved line source by multiple volume sources. Emissions from a line source or narrow volume source represented by multiple volume sources are divided equally among the individual sources unless there is a known spatial variation in emissions. Setting the initial lateral dimension σ_{yo} equal to W/2.15 in Figure 2-10(a) or 2W/2.15 in Figure 2-10(b) results in overlapping Gaussian distributions for the individual sources. If the wind direction is normal to

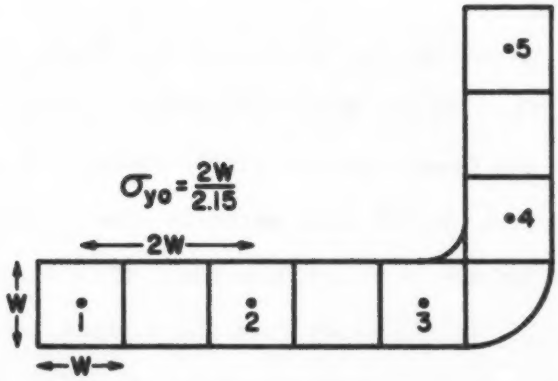
TABLE 2-12

SUMMARY OF SUGGESTED PROCEDURES FOR ESTIMATING INITIAL LATERAL DIMENSIONS (σ_{yo}) AND INITIAL VERTICAL DIMENSIONS (σ_{zo}) FOR VOLUME AND LINE SOURCES

Type of Source		Procedure for Obtaining Initial Dimension
(a) Initial Lateral Dimensions (σ_{yo})		
Single Volume Source	σ_{yo}	= length of side divided by 4.3
Line Source Represented by Adjacent Volume Sources (see Figure 2-10(a))	σ_{yo}	= length of side divided by 2.15
Line Source Represented by Separated Volume Sources (see Figure 2-10(b))	σ_{yo}	= center to center distance divided by 2.15
(b) Initial Vertical Dimensions (σ_{zo})		
Surface-Based Source ($H \sim 0$)	σ_{zo}	= vertical dimension of source divided by 2.15
Elevated Source ($H>0$) on or Adjacent to a Building	σ_{zo}	= building height divided by 2.15
Elevated Source ($H>0$) not on or Adjacent to a Building	σ_{zo}	= vertical dimension of source divided by 4.3


σyo = W/2.15
W
W
1
2
3
4
5
6
7
8
9
10

(a) EXACT REPRESENTATION


σyo = 2W/2.15
2W
W
W
1
2
3
4
5

(b) APPROXIMATE REPRESENTATION

FIGURE 2-10. Exact and approximate representations of a line source by multiple volume sources.

a straight line source that is represented by multiple volume sources, the initial crosswind concentration distribution is uniform except at the edges of the line source. The doubling of σ_{y_o} by the user in the approximate line-source representation in Figure 2-10(b) is offset by the fact that the emission rates for the individual volume sources are also doubled by the user.

There are two types of volume sources: surface-based sources, which may also be modeled as area sources, and elevated sources. An example of a surface-based source is a surface rail line. The effective emission height H for a surface-based source is usually set equal to zero. An example of an elevated source is an elevated rail line with an effective emission height H set equal to the height of the rail line.

2.4.3 The ISC Short-Term Dry Deposition Model

2.4.3.1 General

The Industrial Source Complex short-term dry deposition model is based on the Dumbauld, et al. (1976) deposition model. This model, which is an advanced version of the Cramer, et al. (1972) deposition model, assumes that a user-specified fraction γ_n of the material that comes into contact with the ground surface by the combined processes of atmospheric turbulence and gravitational settling is reflected from the surface (see Section 2.4.1.2.c). The reflection coefficient γ_n, which is a function of settling velocity and the ground surface for particulates and of the ground surface for gaseous pollutants, is analogous in purpose to the deposition velocity used in other deposition models. The Cramer, et al. (1972) deposition model has closely matched ground-level deposition patterns for droplets with diameters above about 30 micrometers, while the more generalized Dumbauld, et al. (1976) deposition model has closely matched observed deposition patterns for both large and small droplets.

Section 2.4.1.2.c discusses the selection of the reflection coefficient γ_n as well as the computation of the gravitational settling velocity V_{sn}. The ISC dry deposition model should not be applied to sources located in elevated terrain. Also, as noted in Section 2.4.1.2.c, uncertainties in the deposition calculations are likely for the A stability category if deposition calculations are made at downwind distances greater than 3.11 kilometers. Deposition and ambient concentration calculations cannot be made in a single program execution. In an individual computer run, the ISC Model calculates either concentration (including the effects of gravitational settling and dry deposition) or dry deposition.

2.4.3.2 Stack and Volume Source Emissions

Deposition for particulates in the n^{th} settling-velocity category or a gaseous pollutant with zero settling velocity V_{sn} and a reflection coefficient γ_n is given by:

$$DEP = K\ Q_T\ V_d D\ (1-\gamma_n)\ \phi_n\ (2\pi\sigma_y\sigma_z x)^{-1}\ \exp\ [-0.5(y/\sigma_y)^2] \qquad (2\text{-}49)$$

where the Vertical Term is defined as follows:

$$V_d = [b\bar{H} + (1 - \bar{b})\ H_v]\ \exp\ [-0.5((H - H_v)/\sigma_z)^2] + \sum_{i=1}^{\infty} (B_1B_2 + B_3B_4)$$

$$B_1 = \gamma^{i-1}\ [\bar{b}H_1 - (1-\bar{b})\ H_v]$$

$$B_2 = \exp\ [-0.5((H_1 + H_v)/\sigma_z)^2]$$

$$B_3 = \gamma^{i}\ [\bar{b}\ H_2 + (1-\bar{b})\ H_v]$$

$$B_4 = \exp\ [-0.5\ ((H_2 - H_v)/\sigma_z)^2]$$

K, D, H_v, H_1, and H_2 were defined previously (Equations (2-19), (2-20), (2-40), and (2-43)). The parameter Q_T is the total amount of material emitted during the time period τ for which the deposition calculation is made. For example, Q_T is the total amount of material emitted during a

1-hour period if an hourly deposition is calculated. For time periods longer than an hour, the program sums the deposition calculated for each hour to obtain the total deposition. The coefficient b is the average value of the exponent b for the interval between the source and the downwind distance x (see Tables 2-7 to 2-10). Values of $\bar{b}$ exist for both the Pasquill-Gifford dispersion coefficients and Briggs-McElroy-Pooler curves. In the case of a volume source, the user must specify the effective emission height H and the initial source dimensions σ_{y_o} and σ_{z_o}.

2.4.3.3 Area Source Emissions

For area source emissions Equation (2-49) is changed to the form:

$$DEP_n = KQ_{A\tau}\ V_dDE\ x_o\ (1-\gamma_n)\ \phi_n(2\pi)^{-1/2}\ (\sigma_z\ x)^{-1} \qquad (2\text{-}50)$$

K, D, and V_d are defined in equations 2-19, 2-20, and 2-49, respectively. The parameter $Q_{A\tau}$ is the total mass per unit area emitted over the time period τ for which deposition is calculated and E is the error function terms defined in equation (2-48).

2.5 The ISC Long-Term Dispersion Model Equations

2.5.1 Stack Emissions

The ISC long-term concentration model makes the same basic assumption as the short-term model. In the long-term model, the area surrounding a continuous source of pollutants is divided into sectors of equal angular width corresponding to the sectors of the seasonal and annual frequency distributions of wind direction, wind speed, and stability (see Figure 2-1). Seasonal or annual emissions from the source are partitioned among the sectors according to the frequencies of wind blowing toward the sectors. The ground-level concentration fields calculated for each source are translated to a common coordinate system (either polar or Cartesian as specified by the user) and summed to obtain the total due to all sources.

For a single stack, the mean seasonal concentration at a point ($r > 1$ m, θ) with respect to the stack is given by:

$$\chi_\ell = 2K\,(2\pi)^{-1/2}\,(r\Delta\theta')^{-1} \sum_{i,j,k} QfSVD(u\sigma_z)^{-1} \tag{2-51}$$

where

Q = pollutant emission rate (mass per unit time), for the i^{th} wind-speed category, k^{th} stability category and ℓ^{th} season

f = frequency of occurrence of the i^{th} wind-speed category, j^{th} wind-direction category and k^{th} stability category for the ℓ^{th} season

$\Delta\theta'$ = the sector width in radians

S = a smoothing function similar to that of the AQDM (see Section 2.5.1.3)

u = mean wind speed (m/sec) at stack height for the i^{th} wind-speed category and k^{th} stability category

σ_z = standard deviation of the vertical concentration distribution (m) for the k^{th} stability category

V = the Vertical Term for the i^{th} wind-speed category, k^{th} stability category and ℓth season

D = the Decay Term for the i^{th} wind speed category and k^{th} stability category

ψ = the decay coefficient (sec^{-1})

K = units scaling coefficient

The mean annual concentration at the point (r,θ) is calculated from the seasonal concentrations using the expression:

$$\chi_a = 0.25 \sum_{\ell=1}^{4} \chi_\ell \tag{2-52}$$

The terms in Equation (2-51) correspond to the terms discussed in Section 2.4.1 for the short-term model except that the parameters are defined for discrete categories of wind-speed, wind-direction, stability and season. The various terms are briefly discussed in the following subsections. In addition to stack emissions, the ISC long-term concentration model considers emissions from area and volume sources. These model options are discussed in Section 2.5.2. The optional algorithms for calculating dry deposition are discussed in Section 2.5.3.

2.5.1.1 The Dispersion Coefficients

a. Point Source Dispersion Coefficients. See Section 2.4.1.1.a for a discussion of the procedures used to calculate the standard deviation of the vertical concentration distribution σ_z for point sources (sources without initial dimensions).

b. Downwind and Crosswind Distances. See the discussion given in Section 2.4.1.1.b.

c. Vertical Virtual Distances. See Section 2.4.1.1.c for a discussion of the procedures used to calculate vertical virtual distances. The lateral virtual distance is given by:

$$x_y = r_o \cot(\Delta\theta'/2) \qquad (2\text{-}53)$$

where r_o is the effective source radius. For volume sources (see Section 2.5.2), the program sets r_o equal to 2.15 σ_{yo}, where σ_{yo} is the initial lateral dimension. For area sources (see Section 2.5.2), the program sets r_o equal to x_o/π where x_o is the length of the side of the area source. For plumes affected by building wakes (see Section 2.4.1.1.d), the program sets r_o equal to 2.15 σ_y' where σ_y' is given for squat buildings by Equation (2-36), (2-37), or (2-38) for downwind distances between 3 and 10 building heights and for tall buildings by Equation (2-39) for downwind distances between 3 and 10 building widths. At downwind distances greater than 10 building heights for Equation (2-36), (2-37), or (2-38), σ_y' is held constant at the value of σ_y' calculated at a downwind distance of 10 building heights. Similarly, at downwind distances greater than 10 building widths for Equation (2-39), σ_y' is held constant at the value of σ_y' calculated at a downwind distance of 10 building widths.

d. Procedures Used to Account for the Effects of Building Wakes on Effluent Dispersion. With the exception of the equations used to calculate the lateral virtual distance, the procedures used to account for the effects of building wake effects on effluent dispersion are the same as those outlined in Section 2.4.1.1.d for the short-term model. The calculation of lateral virtual distances by the long-term model is discussed in Section 2.5.1.1.c above.

e. Procedures Used to Account for Buoyancy-Induced Dispersion. See the discussion given in Section 2.4.1.1.e.

2.5.1.2 The Vertical Term

a. The Vertical Term for Gases and Small Particulates. Except for the use of seasons and discrete categories of wind-speed and stability, the Vertical Term for gases and small particulates corresponds to the short term version discussed in Section 2.4.1.2. The user may assign a separate mixing height H_m to each combination of wind-speed and stability category for each season.

As with the short-term model, the Vertical Term is changed to the form:

$$V = (2\pi)^{1/2} \sigma_z/(2 H_m) \qquad (2\text{-}54)$$

at downwind distances where the σ_z/H_m ratio is greater than or equal to 1.6. Additionally, the ground-level concentration is set equal to zero if the effective stack height H exceeds the mixing height H_m. As explained in Section 2.2.1.2, ISCLT in the Rural Mode currently sets the mixing height equal to a very large value for the E and F stability categories.

b. The Vertical Term in Elevated Terrain. See Section 2.4.1.2.b.

c. The Vertical Term for Large Particulates. Section 2.4.1.2.c discusses the differences in the dispersion of large particulates and the dispersion of gases and small particulates and provides guidance on the use of this option. The Vertical Term for large particulates is given by Equation (2-45).

2.5.1.3 The Smoothing Function

As shown by Equation (2-51), the rectangular concentration distribution within a given angular sector is modified by the function S{θ} which smooths discontinuities in the concentration at the boundaries of adjacent sectors. The centerline concentration in each sector is unaffected by contributions from adjacent sectors. At points off the sector centerline, the concentration is a weighted function of the concentration at the centerline and the concentration at the centerline of the nearest adjoining sector. The smoothing function is given by:

$$S = (\Delta\theta' - |\theta'_j - \theta'|)/\Delta\theta' \quad \text{for } |\theta'_j - \theta'| \leq \Delta\theta' \quad \text{or} \quad = 0 \quad \text{for } |\theta'_j - \theta'| > \Delta\theta' \qquad (2\text{-}55)$$

where

θ'_j = the angle measured in radians from north to the centerline of the j^{th} wind-direction sector

θ' = the angle measured in radians from north to the receptor point (r,θ)

2.5.2 Area, Volume and Line Source Emissions

2.5.2.1 General

As explained in Section 2.4.2.1, the ISC Model area and volume sources are used to simulate the effects of emissions from a wide variety of industrial sources. Section 2.4.2.2 provides guidance on the use of the area source model and Section 2.4.2.3 provides guidance on the use of the volume source model. The volume source model is also used to simulate line sources. The following subsections give the area and volume source equations used by the long-term model.

2.5.2.2 The Long-Term Area Source Model

The seasonal average ground-level concentration at the point (r,θ) with respect to the center of an area source is given by the expression:

$$\chi_A = 2K\, x_o^2 (2\pi)^{-1/2} (R\Delta\theta')^{-1} \sum_{i,j,k} Q_A f S V D\, (u\sigma_z)^{-1} \tag{2-56}$$

where

R = radial distance from the lateral virtual point source to the receptor

$= [(r' + x_y)^2 + y^2]^{1/2}$

D = decay term as follows

$= \exp[-\psi\,(r' - r_o)/u]$

r' = distance from source center to receptor, measured along the plume axis

r_o = effective source radius $= x_o(\pi)^{-1/2}$

y = lateral distance from the cloud axis to the receptor

x_y = lateral virtual distance (see Equation (2-53))

K = units scaling coefficient (see Equation (2-19))

S = smoothing term (see Equation (2-55))

The vertical terms V for gaseous pollutants and small particulates, and for cases with settling and dry deposition, are given in Section 2.4.1.2 with the emission height H defined by the user.

2.5.2.3 The Long-Term Volume Source Model

Equation (2-51) is also used to calculate seasonal average ground-level concentrations for volume sources. The user must assign initial lateral (σ_{yo}) and vertical (σ_{zo}) dimensions and the effective emission height H. A discussion of the application of the volume source model is given in Section 2.4.2.3.

2.5.3 The ISC Long-Term Dry Deposition Model

2.5.3.1 General

The concepts upon which the ISC long-term dry deposition model are based are discussed in Sections 2.4.1.2.c and 2.4.3.1.

2.5.3.2 Stack and Volume Source Emissions

The seasonal deposition at the point (r,θ) with respect to the base of a stack or the center of a volume source for particulates in the n^{th} settling-velocity category or a gaseous pollutant with zero settling velocity V_{sn} and a reflection coefficient γ_n is given by:

$$DEP_{\ell,n} = K\,(1-\gamma_n)\,\phi_n(2\pi)^{-1/2}\,(r^2\,\Delta\theta')^{-1}\sum_{i,j,k}(Q_T fSV_d D(\sigma_z)^{-1} \qquad (2\text{-}57)$$

where the vertical term for deposition, V_d, was defined in Section 2.4.3.2. K and D are described in Equations (2-19) and (2-20), respectively. Q_T is the product of the total time during the ℓ^{th} season, of the seasonal emission rate Q for the i^{th} wind-speed category, k^{th} stability category. For example, if the emission rate is in grams per second and there are 92 days in the summer season (June, July, and August), $Q_{T,\ell=3}$ is given by $7.95 \times 10^6\ Q_{\ell=3}$. It should be noted that the user need not vary the emission rate by season or by wind speed and stability. If an annual average emission rate is assumed, Q_T is equal to 3.15×10^7 Q for a 365-day year. For a plume comprised of N settling velocity categories, the total seasonal deposition is obtained by summing Equation (2-57) over the N settling-velocity categories. The program also sums the seasonal deposition values to obtain the annual deposition.

2.5.3.3 Area Source Emissions

With slight modifications, Equation (2-57) is applied to area source emissions. The user assigns the effective emission height H and Equation (2-57) is changed to:

$$DEP_{\ell,n} = K\ (1-\gamma_n)\ \phi_n\ x_o^2\ (2\pi)^{-1/2}\ (R^2\ \Delta\theta')^{-1} \sum_{i,j,k} (Q_{AT}\ fSV_dD/\sigma_z) \qquad (2\text{-}58)$$

where

Q_{AT} = the product of the total time during the ℓ^{th} season and the emission rate per unit area for the i^{th} wind-speed category and k^{th} stability category

K = units scaling coefficient (Equation (2-19))

D = decay coefficient (Equation (2-20))

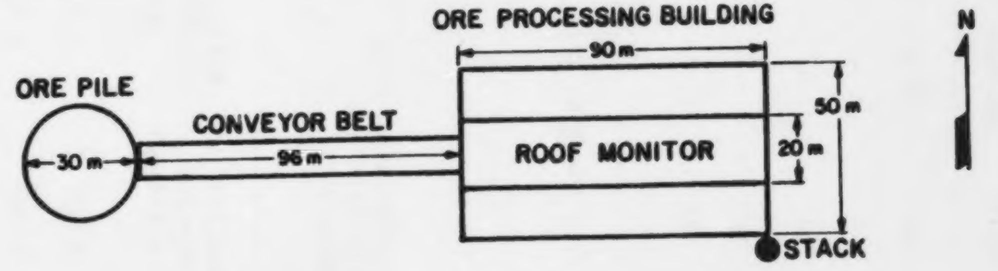
2.6 Example Problem

2.6.1 Description of a Hypothetical Potash Processing Plant

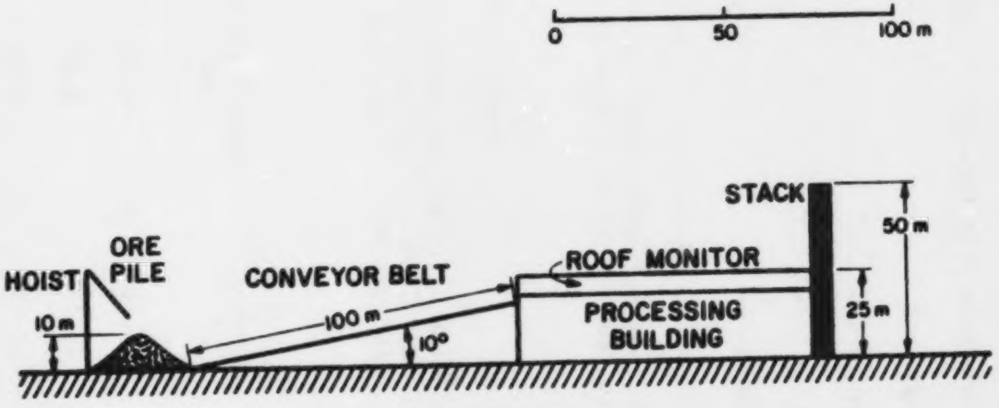
Figure 2-11 shows the plant layout and side view of a hypothetical potash processing plant. Sylvinite ore is brought to the surface from an underground mine by a hoist and dumped on the ore storage pile. The ore then travels along an inclined conveyor belt to the ore processing building where the ore is crushed and screened. Fugitive particulate emissions resulting from the crushing and screening processes are discharged horizontally at ambient temperature from a roof monitor extending the length of the ore processing building. The ore is then refined by froth flotation and sent to the dryers. Particulate emissions produced by the drying process are discharged from a 50-meter stack, located adjacent to the ore processing building, which has a height of 25 meters.

2.6.2 Example ISCST Problem

Table 2-13 gives the emissions data for the hypothetical potash processing plant shown in Figure 2-11. The sylvinite mine and hoist are assumed to operate during the period 0800 to 1600 LST. Fugitive emissions from the ore pile during the period 0800 to 1600 LST are higher than during the period 1600 to 0800 LST because the hoist is continuously dumping sylvinite ore onto the ore pile. A significant fraction of the fugitive emissions from the ore pile and the conveyor belt consists of large particulates. The particle-size distribution, gravitational settling velocities and surface reflection coefficients for particulate emissions from the ore pile and conveyor belt are given in Table 2-14. The settling velocities were calculated using Equations (2-46) and (2-47) with the particulate density assumed to be 1 gram per cubic centimeter; the reflection coefficients were obtained from Figure 2-8. The remainder of the particulate emissions from the hypothetical plant are assumed


ORE PROCESSING BUILDING
90 m
N
ORE PILE
CONVEYOR BELT
50 m
30 m
96 m
ROOF MONITOR
20 m
STACK

(a) PLANT LAYOUT


0
50
100 m
STACK
50 m
ORE PILE
HOIST
CONVEYOR BELT
ROOF MONITOR
10 m
100 m
10°
PROCESSING BUILDING
25 m

(b) SIDE VIEW OF PLANT

FIGURE 2-11. Plant layout and side view of a hypothetical potash processing plant.

TABLE 2-13

EMISSIONS DATA FOR A HYPOTHETICAL POTASH PROCESSING PLANT

Source	Source Ore Pile	 Conveyor Belt	 Roof Monitor	 Main Stack
Particulate emission rate (g/sec)	353.4*	1.3	10.5	5
Emission height (m)	--	--	--	50
Exit velocity (m/sec)	--	--	--	8
Diameter (m)	--	--	--	1.0
Exit temperature (°K)	--	--	--	340

*Emission rate during the period 0800 to 1600 LST. The emission rate during the period 1600 to 0800 LST is 70.7 grams per second.

TABLE 2-14

PARTICLE-SIZE DISTRIBUTION, GRAVITATIONAL SETTLING VELOCITIES AND SURFACE REFLECTION COEFFICIENTS FOR PARTICULATE EMISSIONS FROM THE ORE PILE AND CONVEYOR BELT

Particle Size Category (μ)	Mass Mean Diameter (μ)	Mass Fraction ϕn	Settling Velocity V_{sn} (m/sec)	Reflection Coefficient γ_n
0 - 10	6.30	0.10	0.001	1.00
10 - 20	15.54	0.40	0.007	0.82
20 - 30	25.33	0.28	0.019	0.72
30 - 40	35.24	0.12	0.037	0.65
40 - 50	45.18	0.06	0.061	0.59
50 - 65	17.82	0.04	0.099	0.50

to be submicron particulates so that the effects of gravitational settling and dry deposition need not be included in the model calculations. The purpose of this example problem is to use ISCST to calculate 24-hour average particulate concentrations produced by emissions from the hypothetical potash plant. Additionally, estimates of the dry deposition of fugitive emissions from the ore pile and the conveyor belt are required for each 24-hour period.

The ore pile is modeled as an area source with the effective side x_o of the circular storage pile given by:

$$x_o = 0.5 \pi^{1/2} D \qquad (2\text{-}59)$$

where D is the diameter of the base of the storage pile. The emission height H is set equal to the height of the ore pile (10 meters). The emission rate in grams per second is divided by the horizontal area of the storage pile (706.9 square meters) to obtain the area source emission rate in grams per second per square meter.

The conveyor belt is 10 meters wide and 100 meters long and is inclined at an angle of 10 degrees. Thus, the conveyor belt is modeled as ten 10-meter square volume sources. The initial lateral dimension of each source is obtained by dividing the width (10 meters) by 2.15. The initial vertical dimension σ_{zo} is arbitrarily set equal to 1 meter to account for the effects of local plant roughness elements. The emission height H_i for the i^{th} source is given by:

$$H_i = L_i \sin \theta \qquad (2\text{-}60)$$

where

H_i = the effective emission height for the i^{th} volume source

L_i = the length, measured from the beginning of the conveyor belt, to the center of the i^{th} volume source

θ = the angle of inclination (10 degrees)

The volume source model is also used to model the 90-meter by 20-meter roof monitor. The roof monitor is approximated by four 20-meter square volume sources with the centers of the volume sources spaced at 23.3-meter intervals. The initial lateral dimension σ_{y_o} of each of the four volume sources is obtained by dividing 23.3 meters by 2.15. Because the opening of the roof monitors extends from 20 to 25 meters above plant grade, the emission height H is set equal to 22.5 meters. In order to account for the effects of the aerodynamic wake of the processing building on the initial dispersion of emissions from the roof monitor, the initial vertical dimension σ_{z_o} is obtained by dividing the building height (25 meters) by 2.15.

In summary, the effects of emissions from the hypothetical potash processing plant shown in Figure 2-11 can be simulated by 16 sources. A single area source represents the ore pile, ten volume sources simulate the inclined conveyor belt, four volume sources represent the roof monitor, and there is one stack. It should be noted that the stack height to building height ratio is less than 2.5 so that the ISC Model procedures for evaluating wake effects are applied to the stack emissions. The emissions data for the hypothetical plant given in Table 2-13 are converted to the form required for input to ISCST in Tables 2-15 and 2-16. The information given in Table 2-14 is also required for the ore pile and the conveyor belt. Because the plant is located in open terrain, all source elevations are set equal to zero. The X and Y coordinates assume that the origin of the coordinate system is located at the center of the ore pile. Source combinations that are of interest in analyzing the results of the calculations are as follows:

TABLE 2-15

EMISSIONS INVENTORY IN FORM FOR INPUT TO THE ISC DISPERSION MODEL

Source Number	Source Type*	X (m)	Y (m)	Z (m)	h (m)	V_A (m/sec) - Type 0 σ_{yo} (m) - Type 1 X_o (m) - Type 2	d (m) - Type 0 σ_{zo} - Type 1	T_s (°K) Type 0	H_B (m) Type 0	Q (g/sec) - Type 0 & 1 g/(sec . m^2) - Type 2
1	2	-13.3	-13.3	0	10.0	26.6	--	--	--	5.00×10^{-1}
2	1	20	0	0	0.9	4.7	1.0	--	--	1.30×10^{-1}
3	1	30	0	0	2.6	4.7	1.0	--	--	1.30×10^{-1}
4	1	40	0	0	4.3	4.7	1.0	--	--	1.30×10^{-1}
5	1	49	0	0	6.1	4.7	1.0	--	--	1.30×10^{-1}
6	1	59	0	0	7.8	4.7	1.0	--	--	1.30×10^{-1}
7	1	69	0	0	9.6	4.7	1.0	--	--	1.30×10^{-1}
8	1	79	0	0	11.3	4.7	1.0	--	--	1.30×10^{-1}
9	1	89	0	0	13.0	4.7	1.0	--	--	1.30×10^{-1}
10	1	99	0	0	14.8	4.7	1.0	--	--	1.30×10^{-1}
11	1	109	0	0	16.5	4.7	1.0	--	--	1.30×10^{-1}
12	1	121	0	0	22.5	10.8	11.6	--	--	2.63
13	1	144	0	0	22.5	10.8	11.6	--	--	2.63
14	1	167	0	0	22.5	10.8	11.6	--	--	2.63
15	1	190	0	0	22.5	10.8	11.6	--	--	2.63
16**	0	201	30	0	50.0	8.0	1.0	340	25	5.00

*Source Type 0 = Stack, Source Type 1 = Volume and Source Type 2 = Area.

**Building width is 50 meters and building length is 90 meters (see Figure 2-11).

TABLE 2-16

PARTICLE EMISSION RATES FOR THE ORE PILE

Hour (LST)	Emission Rate Q (g/sec·m^2) A	Total Hourly Emission Q (g/m^2) AT*
0100	0.1	360
0200	0.1	360
0300	0.1	360
0400	0.1	360
0500	0.1	360
0600	0.1	360
0700	0.1	360
0800	0.5	1,800
0900	0.5	1,800
1000	0.5	1,800
1100	0.5	1,800
1200	0.5	1,800
1300	0.5	1,800
1400	0.5	1,800
1500	0.5	1,800
1600	0.1	360
1700	0.1	360
1800	0.1	360
1900	0.1	360
2000	0.1	360
2100	0.1	360
2200	0.1	360
2300	0.1	360
2400	0.1	360

*The amount of material emitted during each hour is required for the deposition calculations.

- Source 1 - Ore Pile
- Sources 2-11 - Conveyor Belt
- Sources 12-15 - Roof Monitor
- Source 16 - Stack
- Sources 1-16 - Plant as a Whole

Example ISCST runs that use the inputs given in Tables 2-13 through 2-16 and the receptor grid shown in Figure 2-3 to calculate concentrations and deposition are given in Appendix C. The hypothetical potash plant is assumed to be located in a rural area. Also, the plant does not contain large surface roughness elements or heat sources. Consequently, the Rural Mode is used in the ISCST calculations.

2.6.3 Example ISCLT Problem

The purpose of this example problem is to use ISCLT to calculate, for the receptor grid shown in Figure 2-3, annual average ground-level particulate concentrations produced by emissions from the hypothetical potash processing plant shown in Figure 2-11 as well as the annual deposition produced by fugitive emissions from the ore pile and conveyor belt. Annual concentration and deposition estimates are also required for an air quality monitoring station located 2,108 meters from the center of the ore pile at a bearing of 014 degrees. With the exception of emissions from the ore pile and the conveyor belt, the emissions data for the plant are assumed to be identical to the data given in Tables 2-15 and 2-16. Fugitive emission rates for the ore pile and conveyor belt are given in Table 2-17 as functions of the wind-speed and Pasquill stability categories. The corresponding annual particulate emissions required for the annual deposition calculations are given in Table 2-18. Example ISCLT runs that calculate annual average concentration and total annual deposition values for this problem are presented in Appendix D.

TABLE 2-17

PARTICULATE EMISSION RATES FOR THE ORE PILE AND CONVEYOR BELT AS FUNCTIONS OF WIND SPEED AND STABILITY

Pasquill Stability Category	Emission Rate for Wind Speeds (m/sec) of					
	0-1.5	1.6-3.1	3.2-5.1	5.2-8.2	8.3-10.8	>10.8
	(a) Ore Pile $Q_{A;i,k}(g/(sec.m^2))$					
A	0.40	0.50	--	--	--	--
B	0.30	0.40	0.50	--	--	--
C	0.20	0.30	0.40	0.50	0.70	1.00
D	0.10	0.25	0.50	0.50	0.70	1.00
E	--	0.20	0.25	--	--	--
F	0.05	0.10	--	--	--	--
(b) Individual volume Sources $Q_{i,k}$ (g/sec) Used to Represent the Conveyor Belt						
A	0.13	0.16	--	--	--	--
B	0.10	0.13	0.16	--	--	--
C	0.08	0.12	0.14	0.16	0.19	0.22
D	0.04	0.10	0.13	0.16	0.19	0.22
E	--	0.08	0.10	--	--	--
F	0.02	0.05	--	--	--	--

TABLE 2-18

ANNUAL PARTICULATE EMISSIONS FOR THE ORE PILE AND CONVEYOR BELT AS FUNCTIONS OF WIND SPEED AND STABILITY

Pasquill Stability Category	Annual Emissions for Wind Speeds (m/sec) of					
	0-1.5	1.6-3.1	3.2-5.1	5.2-8.2	8.3-10.8	>10.8
			(a) Ore Pile $Q_{A_T;i,k}$*			
A	1.26×10^7	1.58×10^7	--	--	--	--
B	9.46×10^6	1.26×10^7	1.58×10^7	--	--	--
C	6.31×10^6	9.46×10^6	1.26×10^7	1.58×10^7	2.21×10^7	3.15×10^7
D	3.15×10^7	7.88×10^6	1.26×10^7	1.58×10^7	2.21×10^7	3.15×10^7
E	--	6.31×10^6	9.46×10^6	--	--	--
F	1.58×10^6	3.15×10^6	--	--	--	--
(b) Individual Volume Sources $Q^{**}_{T;i,k}$ (g) Used to Represent the Conveyor Belt						
A	4.10×10^6	5.05×10^6	--	--	--	--
B	3.15×10^6	4.10×10^6	5.05×10^6	--	--	--
C	2.52×10^6	3.78×10^6	4.42×10^2	5.05×10^6	5.99×10^6	6.94×10^6
D	1.26×10^6	3.15×10^6	4.10×10^6	5.05×10^6	5.99×10^6	6.94×10^6
E	--	2.52×10^6	3.15×10^6	--	--	--
F	6.31×10^5	1.58×10^6	--	--	--	--

*$Q_{A_T;ik}$ (g/m^2) = $Q_{A;i,K}$ (g/(sec.m^2)) × (3600 sec/hr) × (24 hr/day) × (365 day/yr) = 3.1536×10^7 $Q_{A;i,K}$

**Similarly, $Q_{T;i,k}$ (g) = 3.1536×10^7 $Q_{i,k}$ (g/sec)

SECTION 3

USER'S INSTRUCTION FOR THE ISC SHORT-TERM (ISCST) MODEL PROGRAM

3.1 Summary of Program Options, Data Requirements and Output

3.1.1 Summary of ISCST Program Options

The program options of the ISC Dispersion Model short-term computer program (ISCST) consist of three general categories:

- Meteorological data input options
- Dispersion model options
- Output options

Each category is discussed separately below.

a. Meteorological Data Input Options. Table 3-1 lists the meteorological data input options for the ISCST computer program. Hourly meteorological data may be input by card deck or by means of the preprocessed meteorological data tape. Be aware, however, that the calm wind processing feature is not available when meteorological data are input by card deck. In fact, the model will automatically assume meteorology is to be input via tape/file if the regulatory default option is selected. Under these conditions, the model will expect an external meteorology file (which doesn't exist), and terminate abnormally. It is up to the user to insure tape/file input of meteorology when the regulatory default option is selected.

If available, site-specific wind-profile exponents and vertical potential temperature gradients may be input for each stability category or for each combination of wind-speed and stability categories. The Rural Mode, Urban Mode 1, Urban Mode 2 or Urban Mode 3 (see Section 2.2.1.1) may be selected by the user. Also, the user may direct the program to calculate plume rise as a

TABLE 3-1

METEOROLOGICAL DATA INPUT OPTIONS FOR ISCST

Input of hourly data by preprocessed data tape or card deck

Site-specific wind-profile exponents

Site-specific vertical potential temperature gradients

Rural Mode or Urban Mode 1, 2, or 3

Final or distance dependent plume rise

Wind system measurement height if other than 10 meters

TABLE 3-2

DISPERSION-MODEL OPTIONS FOR ISCST

Concentration or dry deposition calculations

Inclusion of effects of gravitational settling and/or dry deposition in concentration calculations

Inclusion of terrain effects (concentration calculations only)

Cartesian or polar receptor system

Discrete receptors (Cartesian or polar system)

Stack, volume and area sources

Pollutant emission rates held constant or varied by hour of the day, by season or month, by hour of the day and season, or by wind speed and stability

Time-dependent exponential decay of pollutants

Inclusion of building wake and stack-tip downwash and buoyancy-induced dispersion effects

Time periods for which concentration or deposition calculations are to be made (1, 2, 3, 4, 6, 8, 12, and 24 hours and N days are possible, where N is the total number of days considered)

Specific days and/or time periods within a day for which concentration or deposition calculations are to be made

Procedure for calm winds processing (not available when meteorological data are input as card images).

function of downwind distance or to assume that the final plume rise applies at all downwind distances. If the wind system measurement height differs from 10 meters, the actual measurement height should be entered.

b. Dispersion Model Options. Table 3-2 lists the dispersion model options for the ISCST computer program. The user may elect to make either concentration or dry deposition calculations. In the case of concentration calculations, the effects of gravitational settling and/or dry deposition may be included in the calculations for areas of open terrain. Terrain effects may be included in the model calculations. A terrain truncation algorithm is applied when the elevation of a receptor exceeds the source height (elevation plus physical height of source). In general, the gravitational settling and dry deposition options should not be used in elevated terrain (see Sections 2.4.1.2.c and 2.4.3). The user may select either a Cartesian or a polar receptor system and may also input discrete receptor points with either system. ISCST calculates concentration or deposition values for stack, volume and area source emissions. The volume source option is also used to simulate line sources (see Section 2.4.2.3). Pollutant emission rates may be held constant or varied by hour of the day, by season or month, by hour of the day and season, or by wind speed and stability. The effects of time-dependent exponential decay of a pollutant as a surrogate for chemical transformation or other removal processes may also be included in the model calculations (see Section 2.4.1). If a stack is located on or adjacent to a building, the user must input the building dimensions (length, width, and height) in order for the program to consider the effects of the building's aerodynamic wake on plume dispersion. The user must select the time periods over which concentration is to be averaged or deposition is to be summed. The user must also select the specific days and/or time periods within specific days for which concentration or deposition calculations are to be made. For example, the user may wish to calculate 3-hour average concentrations for the third 3-hour period on Day 118. When the calm winds processing option is selected by the user (or by selection of the regulatory default option), calm winds are treated as described in EPA (1984).

c. Output Options. Table 3-3 lists the ISCST program output options. A more detailed discussion of the ISCST output information is given in Section 3.1.3.

The results of all ISCST calculations may be stored on a disc file. The user may also elect to print one or more the following tables:

- The program control parameters, source data, and receptor data.
- Hourly meteorological inputs for each specified day.
- The "N"-day average concentration or "N"-day total deposition calculated at each receptor for any desired combinations of sources.
- The concentration or deposition values calculated for any desired combinations of sources at all receptors for any specified day or time period within a day.
- The highest, second-highest and third-highest concentration or deposition values calculated for any desired combinations of sources at each receptor for each specified averaging time (concentration) or summation time (deposition) during an "N"-day period.
- The maximum 50 concentration or deposition values calculated for any desired combinations of sources for each specified averaging time (concentration) or summation time (deposition).

It should be noted that a given problem run may generate a large print output (see Section 3.2.5.b). Consequently, it may be more convenient to make multiple program runs for a given problem. Note, also, that all output options remain available with the calm wind processing and regulatory default options.

TABLE 3-3

ISCST OUTPUT OPTIONS

Results of the calculations stored on a disc file

Printout of program control parameters, source data and receptor data

Printout of tables of hourly meteorological data for each specified day

Printout of "N"-day average concentration or total deposition calculated at each receptor for any desired combinations of sources

Printout of the concentration or deposition values calculated for any desired combinations of sources at all receptors for any specified day or time period within the day

Printout of tables of highest, second-highest and third-highest concentration or deposition values calculated at each receptor for each specified time period during an "N"-day period for any desired combinations of sources

Printout of tables of the maximum 50 concentration or deposition values calculated for any desired combinations of sources for each specified time period

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3.1.2 Data Input Requirements

This section provides a description of all input data parameters required by the ISCST program. The user should note that some input parameters are not read or are ignored by the program, depending on what values control parameters have been assigned by the user. Except where noted, all data are read from card images.

a. Program Control Parameter Data. These data contain parameters which provide user-control of all program options.

Parameter Name	
ISW(1)	Concentration/Deposition Option -- Directs the program to calculate either average concentration or total deposition. A value of "1" indicates average concentration and a "2" indicates total deposition. The default value equals "1".
ISW(2)	Receptor Grid System Option -- Specifies whether a right-handed rectangular Cartesian coordinate system or a polar coordinate system is used to reference the receptor grid. A value of "1" indicates the Cartesian coordinate system, and "2" indicates the polar coordinate system. Additionally, a "3" value will automatically generate a grid system using the Cartesian coordinate system and a "4" value will automatically generate the polar coordinate direction radials with user-defined starting locations and spacing distances. The default value equals "1".
ISW(3)	Discrete Receptor Option -- Specifies whether a right-handed rectangular Cartesian coordinate system or a polar coordinate system is used to reference discrete receptor points. A value of "1" indicates the Cartesian coordinate system and a "2" indicates the polar coordinate system. The default value equals "1".
ISW(4)	Receptor Terrain Elevation Option -- Allows the user to input terrain elevations for all receptor points. A value of "1" directs the program to read user-provided terrain elevations in feet. A value of "0" assumes level terrain and no terrain elevations are read by the program. The default value equals "0". If equal to "-1", the program assumes input elevations are in meters rather than feet.

Parameter Name	
ISW(5)	Output File Option - Allows all calculated average concentration or total deposition values to be written onto a disc file. A value of "1" writes calculated values to an output file. Refer to Section 3.2.4.b for a complete description of the output produced from the use of this option. A "0" value does not write any calculations to an output file. The default value equals "0".
ISW(6)	Print Input Data Option -- Allows the user to print all input data parameters. A value of "0" indicates no input data are listed. A "1" indicates that all program control parameters and model constants, receptor site data and source data are printed. A "2" value is the same as the "1" option except that all hourly meteorological data used in the calculations are also printed. The default value equals "0".
ISW(7)- ISW(14)	Time Period Options -- These options allow the user to compute average concentration or total deposition based on up to eight time periods. Parameters ISW(7) through ISW(14) respectively correspond to 1-, 2-, 3-, 4-, 6,- 8-, 12-, and 24-hour time periods. The user may choose any number of the eight time periods. A value of "1" for any of the eight parameters directs the program to compute average concentration or total deposition values for the corresponding time period. A "0" value for any of the eight time-period parameters directs the program not to make calculations for the corresponding time period. The default values equals "0".
ISW(15)*	Output "N"-day Table Option -- Allows the user to print average concentration or total deposition for the total number of days of meteorological data processed by the problem run for source group combinations chosen by the user. A value of "1" employs this option; "N"-day tables are not printed if ISW(15) has a "0" value. The default value equals "0".
ISW(16)*	Output Daily Tables Option -- Allows the user to print average concentration or total deposition values for all time periods and source groups specified by the user for each day of meteorological data processed. A value of "1" directs the program to print these tables; these tables are not printed if ISW(16) has a "0" value or if parameters ISW(7) through ISW(14) equal "0". The default value equals "0".
ISW(17)*	Output Highest, Second-Highest and Third-Highest Tables Option -- Allows the user to print the highest and second-highest average concentration or total deposition calculated at each receptor. A set of the highest and second-highest tables is

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*The four parameters ISW(15) through ISW(18) pertain to output table options. Refer to Section 3.1.3 for a more complete summary of the contents of each type of output table.

Parameter Name	
ISW(17)* (Cont.)	printed for each time period and source group combination chosen by the user. A value of "1" directs the program to print these tables; these tables are not printed if ISW(17) has a "0" value or if parameters ISW(7) through ISW(14) equal "0". A value of "2" will cause the program to print a third highest table in addition to the highest and second highest tables. Default value equals "0".
ISW(18)*	Output Maximum 50 Tables Option -- Specifies whether or not tables of the 50 highest calculated average concentration or total deposition values are printed for each time period and source group specified by the user. A "1" value employs this option; these tables are not printed if ISW(18) has a "0" value or if parameters ISW(7) through ISW(14) equal "0". The default value equals "0".
ISW(19)	Meteorological Data Option -- A "1" value directs the program to read hourly meteorological data from FORTRAN logical unit IMET in a format compatible with that generated by the pre-processor program. A "2" value directs the program to read hourly meteorological data in a card image format. The default value equals "1". The user should recall that if the regulatory default option (ISW (28)) selected, the model automatically assumes pre-processed meteorological data are to be used (ISW (19) = 1).
ISW(20)	Rural/Urban Option -- Specifies which of the rural or three urban modes is to be used. A value of "0" directs the program to read rural mixing heights. A "1" value causes the program to read urban mixing heights with Urban Mode 1 adjustments to the input stability categories (see Table 2-3). A "2" value causes the program to read urban mixing heights with Urban Mode 2 adjustments to the input stability categories. The Pasquill-Gifford dispersion curves are used for the Rural Mode and Urban Modes 1 and 2. A value of "3" directs the program to read urban mixing heights and use the Briggs urban dispersion curves (Urban Mode 3). The default value equals "0". It should be noted that if Meteorological Data Option (ISW(19)) has a value of "2", the program automatically assigns a "0" value to ISW(20), unless Urban Mode 3 is selected, and ignores any conflicting value entered by the user. It should be noted that the use of Urban Modes 1 and 2 are not recommended for regulatory purposes.
ISW(21)	Wind Profile Exponent Option -- This option allows the user to enter wind profile exponent values or allows the program to provide default wind profile exponent values. If a value of "1" is entered, the program provides default values. See

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*The four parameters ISW(15) through ISW(18) pertain to output table options. Refer to Section 3.1.3 for a more complete summary of the contents of each type of output table.

Parameter Name	
ISW(21) (Cont'd.)	Table 2-2 for the default values used by the program. If a value of "2" is entered, the program reads user-provided wind profile exponents in input parameter PDEF. These values remain constant throughout the problem run. If a value of "3" is entered, the program reads user-provided wind profile exponent values in input parameter P for each hour of meteorological data processed by the program. Note that the ISW(21) equals "3" option assumes the hourly meteorological data are in a card image format (ISW(19) = "2"). The default value of ISW(21) equals "1". The regulatory default option (ISW(28)) also sets ISW(21) to "1".
ISW(22)	Vertical Potential Temperature Gradient Option -- This option allows the user to enter vertical potential temperature gradient values or allows the program to provide default vertical potential temperature gradient values. If a value of "1" is entered, the program provides default values. See Table 2-2 for the default values used by the program. If a value of "2" is entered, the program reads user-provided vertical potential temperature gradient values in input parameter DTHDEF. These values remain constant throughout the problem run. If a value of "3" is entered, the program reads user-provided vertical potential temperature gradient values in input parameter DTHDZ for each hour of meteorological data processed by the program. Note that the ISW(22) equals "3" option assumes hourly meteorological data are in a card image format (ISW(19) equals "2"). The default value of ISW(22) equals "1". The regulatory default option (ISW(28)) also sets ISW(22) to "1".
ISW(23)	Variable Source Emission Rate Option -- Allows the user to specify scalars which are multiplied by the sources' average emission rates. This parameter is employed by the user when it is desired to vary the average emission rates for all sources. It is also possible to vary the emission rates for individual sources with the QFLG parameter option. These scalars may vary as a function of season, month, hour of the day, hour of the day and season, or wind speed and stability category. A value of "1" allows the user to enter four seasonal scalars; a "2" allows the user to enter twelve monthly scalars; a "3" allows the user to enter twenty-four scalars for each hour of the day; a "4" value allows the user to enter thirty-six scalars for six wind speed categories for each of the six stability categories; a "5" value allows the user to enter ninty-six scalars for twenty-four hourly values for each of the four seasons. A "0" value directs the program not to vary average emission rates for all sources, and allows the use of the QFLG parameter option for the individual sources. The default value of this parameter equals "0".

Parameter Name	
ISW(24)	Plume Rise Option -- Allows the program to consider only the final plume rise at all downwind receptor locations if a value of "1" is entered. If a value of "2" is entered, the program computes plume rise as a function of the downwind distance of each receptor. The default value of ISW(24) equals "1". The regulatory default option (ISW(28)) also sets ISW(24) to "1".
ISW(25)	Stack-Tip Downwash Option -- Allows the program to use the physical stack height entered by the user or to modify the physical stack height of all stack-type sources entered in order to account for stack-tip downwash effects (Briggs, 1973). If a value of "1" is entered, all physical stack heights entered by the user are used throughout the problem run; if a value of "2" is entered, all physical stack heights entered are modified to account for stack-tip downwash. The default value of ISW(25) equals "1". The regulatory default option (ISW(28)) sets ISW(25) to "2".
ISW(26)	Buoyancy-Induced Dispersion Option -- Allows the program to modify the dispersion coefficients to account for buoyancy-induced dispersion. A value of "1" directs the program to modify the dispersion coefficients for stack-type sources while a "2" directs the program to bypass the modifications. The regulatory default option (ISW(28)) sets ISW(26) to "1".
ISW(27)	Calm Processing Option -- Allows the program to use a calm processing routine, developed by EPA, to calculate concentration or deposition during calm periods. A value of "1" directs the program to use this feature and a "2" directs the program to ignore this feature.
ISW(28)	Regulatory Default Option -- If chosen, the program will internally re-define some user input to produce a simulation consistent with EPA regulatory recommendations. The following features are incorporated when this option is selected (ISW(28)=1): 1. Tape/file meteorological input is assumed. 2. Final plume rise is used at all downwind receptor locations. 3. Stack-tip downwash effects are included. 4. Buoyancy-induced dispersion effects are parameterized. 5. Default wind profile coefficients are assigned (.07, .07, .10, .15, .35, .55 for the rural mode; and .15, .15, .20, .25, .30, .30 for the urban modes). 6. Default vertical potential temperature gradients are assigned (A:0.0, B:0.0, C:0.0, D:0.0, E:0.02, F:0.035 K/m) 7. A calm processing routine is used to handle concentrations during calm periods. 8. A decay half life of 4 hours is assigned if SO_2 is modeled in an urban mode; otherwise, no decay is assigned.

Parameter Name	
ISW(28) (Cont.)	Note, if this option is chosen, ISW (19) is set to "1", indicating input of pre-processed meteorolgical data. Note that the model also selects the appropriate urban or rural mixing height, and that building downwash is calculated when appropriate. This option is not selected if ISW(28)=2.
ISW(29)	Pollutant Indicator Switch -- If SO_2 is modelled the user should set this option equal to "1". If a pollutant other than SO_2 is modelled the user should set this option equal to "2".
ISW(30)	Input Debug Switch - If the user wants input data printed as soon as it is read set this option to "1". Otherwise set this option to "2". Note, this option will print the same information as that with ISW(6), but immediately after it is read, providing the user with assistance in determining where in the runstream input errors are located.
NSOURC	Number of Sources -- This parameter specifies the total number of sources to be processed by the problem run.
NXPNTS	X-Axis/Range Receptor Grid Size -- This parameter specifies the number of east-west receptor grid locations for the Cartesian coordinate system X-axis, or the number of receptor grid ranges (rings) in the polar coordinate system (depending on which receptor grid system is chosen by the user with parameter ISW(2)). A "0" value causes the program to assume that no regular (non-discrete) receptor grid is used.
NYPNTS	Y-Axis/Radial Receptor Grid Size -- This parameter specifies the number of north-south receptor grid locations for the Cartesian coordinate system Y-axis, or the number of receptor grid direction radials in the polar grid system (depending on which receptor grid system is chosen by the user with parameter ISW(2)). A "0" value causes the program to assume that no regular (non-discrete) receptor grid is used.
NXWYPT	Number of Discrete Receptors -- This parameter indicates the total number of discrete receptors to be processed by the problem run. A "0" value causes the program to assume that no discrete receptors are used.
NGROUP	Number of Source Groups -- This parameter specifies the number of source groups desired. Each source group consists of any desired combination of sources. A "0" value defines one source group which consists of all sources. The default value equals "0". A maximum of 150 source groups are allowed.

Parameter Name	
IPERD	Single Time Period Interval Option -- This parameter allows the user to specify one time period interval out of all possible time period intervals within a day. The use of this option directs the program to print only one time period interval specified for daily output tables (see Section 3.1.3.b). For example, if the user desires to print only the fifth 3-hour time period, IPERD requires a value of "5". Also, parameter ISW(9) must equal "1" in order to compute average concentration or total deposition based on a 3-hour time period. A "0" value directs the program to consider all intervals of a given time period.
NHOURS	Number of Hours Per Day of Hourly Meteorological Data -- This parameter is used only when hourly meteorological data are read from card images (parameter ISW(19) equals "2"). This parameter specifies the number of hours per day of meteorological data. For example, one need not enter 24 hours of meteorological data in order to calculate a 3-hour average concentration from only 3 hours of meteorological data.
NDAYS	Number of Days of Meteorological Data -- This parameter is used only when hourly meteorological data are read from card images (parameter ISW(19) equals "2"). This parameter specifies the total number of days of meteorological data to be processed by the program. The default value assumes one day (a value equal to "1") of meteorological data.
NSOGRP	Number of Sources Defining Source Groups -- This parameter is not read if the parameter NGROUP has a "0" value. This parameter is an array of NGROUP values which indicates how many source identification numbers are read by the program in order to define each source group. The source identification numbers themselves are read in parameter IDSOR. Refer to parameter IDSOR for an example of the use of the parameter NSOGRP in association with parameter IDSOR. A maximum of 150 source groups may be used.
IDSOR	Source Identification Numbers Defining Source Groups -- This parameter is not read if parameter NGROUP has a "0" value. This parameter is an array which contains the source identification numbers and/or the lower and upper bounds of source identification number to be summed over, which are used to define a source group. This parameter is used in association with parameter NSOGRP discussed above. The following should illustrate the interactive use of parameters NGROUP, NSOGRP and IDSOR. Let us assume that we have 50 sources who identification numbers are 10, 20, 30, . . ., 490, 500. First, if one desires only to see the average concentration or total deposition calculated from all sources, the parameter NGROUP should equal "0". The parameters NSOGRP and IDSOR are not required by the program and are not input by the user. Next, let us assume that one desires to see the

Parameter Name	
IDSOR (Cont'd.)	average concentration or total deposition contribution individually of sources with identification number 10, 100, 200, 300, 400, and 500 as well as the combined contributions of sources with number 10 through 100, 50 through 260, 100 through 200 plus 400 through 500, and of all sources combined (10 through 500). Hence, the average concentration or total deposition contributions from six individual sources are desired plus the contributions from each of four sets of combined sources for a total of ten source groups. Thus, a value of "10" must be entered for parameter NGROUP. For parameter NSOGRP, one enters the ten values: 1, 1, 1, 1, 1, 1, 2, 2, 4, and 2. For parameter IDSOR, one enters the source identification numbers: 10, 100, 200, 300, 400, 500, 10, -100, 50, -260, 100, -200, 400, -500, 10, -500. Now let us examine the relationship between those values entered in parameters NSOGRP and IDSOR. The first six entries of both NOSGRP and IDSOR are in a one-to-one correspondence; the "1" value entered in parameter NSOGRP implies that only one source identification number is read by the program in the IDSOR array in order to define a complete source group. The seventh entry in parameter NSOGRP (a "2") indicates that the source identification numbers 10 and -100 (the seventh and eighth entries in IDSOR) define a source group. The minus sign preceding source identification number "100" indicates to the program to inclusively sum over all sources with identification numbers ranging from "10" to "100". The user need not be concerned by the fact that no source number of, say, "43" exists. The program only sums over those source numbers defined (in this case, 10, 20, 30, . . ., 90, 100). The eighth entry in parameter NSOGRP (a "2") specifies a source group including source numbers "50" through "260" which are the next set of values in parameter IDSOR. If one desires to see source contributions from consecutive source numbers, and also desires to exclude some source numbers, the next entry in parameter NSOGRP (a "4") illustrates this procedure. The value "4" implies that four source numbers are read by the program in order to define a source group. The four source identification numbers read by the program in parameter IDSOR, which are the source numbers following the last source numbers used to define the preceding source group, are 100, -200, 400, -500. This arrangement implies that inclusive summing over all sources from "100" to "200" and "400" to "500" is desired, excluding source numbers "210" to "390". Finally, it is still possible to obtain the combined contribution from all sources as shown in the last source group. In summary, we have: (1) Parameter NGROUP is a value which represents the number of source groups desired; (2) The values in parameter NSOGRP indicate the number of source identification numbers read by the program in parameter IDSOR; and, (3) parameter IDSOR contains the source identification numbers used to define a source group, where a minus sign preceding a source number implies inclusive summing from the previous source number entered to the source number with the minus sign. The number of source identification numbers cannot exceed two hundred values for parameter IDSOR.

b. Meteorological-Related Constants. These data consist of parameters related to the meteorological conditions of the problem run. They are constants which are initialized at the beginning of the problem run and remain constant throughout the problem run (as opposed to the hourly meteorological data which change throughout the problem run).

Parameter Name	
PDEF	Wind Profile Exponents -- These data are read by the program only if option ISW(21) has a value equal to "2" and the regulatory default option is not chosen (ISW(28) = 2. This parameter is an array containing wind profile exponents for six stability categories, where each stability category contains six values for the six wind speed categories. A total of thirty-six wind profile exponents are entered by the user. See Table 2-2 for default values.
DTHDEF	Vertical Potential Temperature Gradients -- These data are read by the program only if option ISW(22) has a value equal to "2" and the regulatory default option is not chosen (ISW(28) = 2. This parameter is an array containing vertical potential temperature gradients (degrees Kelvin/meter) for six stability categories, where each stability category contains six values for the six wind speed categories. A total of thirty-six vertical potential temperature gradients are entered by the user. See Table 2-2 for default values.
UCATS	Wind Speed Categories -- This parameter contains five values which specify the upperbound of the first through fifth wind speed categories (meters/second). The program assumes no upper limit on the sixth wind speed category. The default values equal 1.54, 3.09, 5.14, 8.23, and 10.8 meters per second for the first through fifth categories, respectively.
ZR	Wind Speed Reference Height -- This parameter specifies the height (meters) at which the wind speed was measured. The default value equals 10.0 meters.
DECAY*	Decay Coefficient -- This parameter is the decay coefficient (seconds^{-1}) used to describe decay of a pollutant due to chemical depletion. If SO_2 is modelled in an Urban Mode and the regulatory default option is chosen, the program assigns a decay coefficient coresponding to a half life of four hours. Otherwise, pollutant decay is not considered.

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*This parameter is read by the program only if the hourly meteorological data are in a preprocessed format (parameter ISW(19) equals "1").

Parameter Name	
IDAY*	Meteorological Julian Day Indicator -- This parameter consists of an array of 366 entries, where each entry indicates whether or not a meteorological day of data is processed by the program. The entry number of the array corresponds to the Julian Day of meteorological data. For example, the 140th entry IDAY(140) corresponds to Julian Day 140. An entry with a "1" value directs the program to process the corresponding day of meteorological data. A "0" value directs the program to ignore that corresponding day. The default assumes "0" values for all 366 entries.
USS*	Surface Station Number -- This parameter specifies the surface station number of the meteorological data being used. The surface station number usually corresponds to the WBAN station identification number for a given observation station. The number is usually a five-digit integer.
ISY*	Year of Surface Station Data -- This parameter specifies the year of the surface station meteorological data. Only the last two digits of the year are entered.
IUS*	Upper Air Station Number -- This parameter specifies the upper air station number of the meteorological data being used. The upper air station number usually corresponds to the WBAN station identification number for a given observation station. The number is usually a five-digit integer.
IUY*	Year of Upper Air Station Data -- This parameter specifies the year of upper air station meteorological data. Only the last two digits of the year are entered.

c. Identification Labels and Model Constants. These data consist of parameters pertaining to heading and identification labels and program constants.

Parameter Name	
TITLE	Heading Label -- This parameter allows the user to enter up to 60 characters in order to identify a problem run. The information entered in this parameter appears at the top of each page of print output.

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*This parameter is read by the program only if the hourly meteorological data are in a preprocessed format (parameter ISW(19) equals "1").

Parameter Name	
IQUN	Source Emission Rate Label -- This parameter provides the user with up to 12 characters in order to identify the emission rate units of all sources. The default label is (GRAMS/SEC) when calculating average concentration and (GRAMS) when calculating total deposition. All area source emission rate labels automatically include units of per square meter.
ICHIUN	Output Units Label -- This parameter provides the user with a 28-character label in order to identify the units of average concentration or total deposition. The default value is (MICROGRAMS/CUBIC METER) for average concentration calculations and (GRAMS/SQUARE METER) for total deposition calculations.
TK	Source Emission Rate Conversion Factor -- This parameter allows the user to scale the source emission rate for all sources in order to convert the emission rate units. This parameter is used in conjunction with label parameters IQUN and ICHIUN. The default value equals 1.0×10^6 for average concentration calculations and 1.0 for total deposition calculations.
IMET	FORTRAN Logical Unit Number for Hourly Meteorological Data -- This parameter specifies the FORTRAN logical unit number of the device from which the hourly meteorological data are read. The default value equals "9" for hourly meteorological data which are in a preprocessed format. The default value for card image meteorological data is the same as the logical unit number for all card input data.
ITAP	FORTRAN Logical Unit Number of Output Disc File -- This parameter is ignored by the program if no output file is generated by the problem run (ISW(5) equals "0"). This parameter specifies the FORTRAN logical unit number of the output device. The default value equals "3".

d. Receptor Data. These data consist of the (X, Y) or (range, theta) locations of all receptor points. Also included are the receptor terrain elevations. The minimum distance in meters between source and receptor for which calculations are made is given by:

Stack Sources:

$$\text{minimum distance} = \begin{cases} 1 & \text{; no wake effects} \\ \text{or} & \\ \text{MAX(1,3*HB)} & \text{; wake effects, squat building} \\ \text{or} & \\ \text{MAX(1,3*HW)} & \text{; wake effects, tall building} \end{cases}$$

Volume Sources:

minimum distance = 1 + 2.15*SIGYO

Area Sources:

minimum distance = 1 + 0.5*BW

Where:

HB = height of building
HW = width of building
SIGYO = standard deviation of the lateral source dimension of building
BW = width of area source

Parameter Name	
GRIDX	Receptor Grid X-Axis or Range Data -- This parameter is read by the program only if input parameters NXPNTS and NYPNTS are both greater than zero. This parameter is an array which has different functions depending on the value of ISW(2). If ISW(2) equals "1", this parameter contains NXPNTS values of the X-axis receptor grid points (meters). If ISW(2) equals "2" or "4", this parameter contains NXPNTS values of the receptor grid ranges (rings) in meters. If ISW(2) equals "3", the first entry of this parameter contains the starting location (meters) of the X-axis receptor grid and the second entry contains the incremental value (meters) with which the remaining NXPNTS values of the X-axis are generated.
GRIDY	Receptor Grid Y-Axis or Direction Radial Data -- This parameter is read by the program only if input parameters NXPNTS and NYPNTS are both greater than zero. This parameter is an array which has different functions depending on the value of ISW(2). If ISW(2) equals "1", this parameter contains NYPNTS values of the Y-axis receptor grid points (meters). If ISW(2) equals "2", this parameter contains NYPNTS values of the direction radials (degrees) for the receptor grid. The program requires that these values not be fractional values but integer values within the range of 1 to 360 degrees. The default value equals "360" degrees. If ISW(2) equals "3", the first entry of this parameter contains the starting location (meters) of the Y-axis receptor grid and the second entry contains the incremental value (meters) with which the remaining NYPNTS values of the Y-axis are generated. If the ISW(2) equals "4", the first entry of this parameter contains the starting direction radial location (degrees) of the receptor grid and the second entry contains the incremental value (degrees) with which the remaining NYPNTS direction radial values of the receptor grid are generated. All values generated must be integers within the range of 1 to 360 degrees. The default value equals "360" degrees.

GRIDZ (non-discrete)	Grid Receptor Terrain Elevation Data -- This parameter is read only if parameter ISW(4) equals "1" (feet) or "-1" (meters) and NXPNTS and NYPNTS are both greater than zero. This parameter is an array which contains all the receptor terrain elevations for the receptor grid. Receptor elevation Z_{ij} corresponds to the i^{th} X coordinate (range) and j^{th} Y coordinate (direction radial). Begin with Z_{11} and enters NXPNTS values (Z_{11}, Z_{21}, Z_{31}, . . .). Then, starting with a new card image, enter NXPNTS values (Z_{12}, Z_{22}, Z_{32}, . . .). Continue until all regular receptor elevations have been entered.
XDIS	Discrete Receptor X or Range Data -- This parameter is read by the program only if parameter NXWYPT is greater than zero. This parameter is an array which has different functions depending on the value of parameter ISW(3). If ISW(3) equals "1", this parameter contains NXWYPT discrete receptor X locations (meters). If ISW(3) equals "2", this parameter contains NXWYPT discrete receptor range locations (meters). The values entered in this parameter are used in association with those in parameter YDIS.
YDIS	Discrete Receptor Y or Direction Data -- This parameter is read by the program only if NXWYPT is greater than zero. This parameter is an array which has different functions depending on the value of parameter ISW(3). If ISW(3) equals "1", this parameter contains NXWYPT discrete receptor Y locations (meters). If ISW(3) equals "2", this parameter contains NXWYPT discrete receptor direction values (degrees). These direction values must not be fractional in value, but integer values within the range of 1 to 360 degrees where the default value is "360" degrees. The values entered in this parameter are used in association with those in parameter XDIS.
GRIDZ (discrete)	Discrete Receptor Terrain Elevation Data -- This parameter is only read if ISW(4) = "1" (feet) or "-1" (meters) and NXWYPT is non-zero. This parameter is an array of receptor terrain elevations for discrete receptors.

e. Source Data. These data consist of all necessary information required for each source entered by the user. Because the program can process three types of sources (stack, volume, and area), some source types require more information than other types. The following input parameters are required by all source types.

Parameter Name	
NSO	Source Identification Number -- This parameter is a number which uniquely identifies each source. The program uses this identification number for any output tables that are generated requiring individual source identification. This number must be a positive number.
ITYPE	Source Type Indicator -- This parameter specifies the type of source. If a value of "0" is entered, this is a stack-type source. Similarly, a "1" is entered for a volume-type source. A "2" is entered for an area-type source. Consult Sections 2.4.1 and 2.4.2 for a technical discussion of these source types.
NVS	Number of Gravitational Settling Categories -- This parameter specifies the number of gravitational settling categories to be considered. This parameter is used for sources with particulates or droplets with significant gravitational settling velocities. A maximum of 20 categories is allowed for each source.
QFLG	Variable Source Emission Rate Option -- This parameter is ignored by the program if ISW(23) has a non-zero value. This parameter allows the user to specify scalars which are multiplied by this individual source's average emission rate. These scalars may vary as a function of season, month, hour of the day, season and hour of the day, or stability category and wind speed. The implementation of this parameter is the same as that of parameter ISW(23). Refer to the description of parameter ISW(23) for an explanation of what values are associated with each variational function.
Q	Emission Rate -- This parameter specifies the average emission rate of the source. If average concentration is calculated, the units for stack and volume sources are mass per time and for area sources are mass per square meter per time. If total deposition is calculated, the units for stack and volume sources are mass and for area sources are mass per square meter.
XS	X Location -- This parameter specifies the relative X location (meters) of the center of a stack or volume source and of the southwest corner of an area source.
YS	Y Location -- This parameter specifies the relative Y location (meters) of the center of a stack or volume source and of the southwest corner of an area source.
ZS	Source Elevation -- This parameter specifies the elevation (meters above mean sea level) of the source at the source base.

Stack-Source Parameter	
WAKE	Supersquat Building Wake Effects Equation Option -- This option is used to control the equations used in the calculation of the lateral virtual distance (Equations (2-35) and (2-36) when the effective building width to height ratio (BW/HB) is greater than 5. If this parameter is not punched or has a value of "0" and the width to height ratio is greater than 5, the program will use Equation (2-35) to calculate the lateral virtual distance producing the upper bound of the concentration or deposition of the source. If this parameter has a value of "1", the program uses Equation (2-36) producing the lower bound of the concentration deposition for the source. The appropriate value for this parameter depends on building shape and stack placement with respect to the building (see Section 2.4.1.1.d).
HS	Stack Height -- This parameter specifies the height of the stack above the ground (meters).
TS	Stack Exit Temperature -- This parameter specifies the stack exit temperature in degrees Kelvin. If this value is less than the ambient air temperature for a given hour, the program sets this parameter equal to the ambient air temperature.
VS	Stack Exit Velocity -- This parameter specifies the stack exit velocity in meters per second.
D	Stack Diameter -- This parameter specifies the inner stack diameter in meters.
HB*	Building Height -- This parameter specifies the height of a building adjacent to this stack (meters).
HL*	Building Length -- This parameter specifies the length of a building adjacent to this stack (meters).
HW*	Building Width -- This parameter specifies the width of a building adjacent to this stack (meters). The effective width used by the program is the diameter of a circle of equal area to the rectangle given by HL and HW.

Volume-Source Parameters	
H	Center Height -- This parameter specifies the height of the center of the volume source above the ground (meters).

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*If non-zero values are entered for parameters HB, HL, and HW, the program automatically uses the building wake effects option (see Section 2.4.1.1.d). However, if HB, HL, and HW are not punched, or are equal to "0", wake effects for the respective source are not considered.

Volume-Source Parameters

SIGZO	Initial Vertical Dimension -- This parameter specifies the initial vertical dimension σ_{z_0} of the volume source (meters).
SIGYO	Initial Horizontal Dimension -- This parameter specifies the initial horizontal dimension σ_{y_0} of the volume source (meters).

Area-Source Parameters

H	Effective Emission Height -- This parameter specifies the effective emission height of the area source (meters).
XO	Area Source Width -- This parameter specifies the width x_0 of the square area source (meters).

Gravitational Settling Category Parameters

PHI	Mass Fraction -- This parameter is an array which specifies the mass fraction of particulates for each settling velocity category. A maximum of 20 values per source may be entered.
VSN	Settling Velocity -- This parameter is an array which specifies the gravitational settling velocity (meters/second) for each settling velocity category. A maximum of 20 values per source may be entered.
GAMMA	Surface Reflection Coefficient -- This parameter is an array which contains the surface reflection coefficient for each settling velocity category. A maximum of 20 values per source may be entered.
QTK	Source Emission Rate Scalars -- This parameter is applicable only to sources whose emission rates are multiplied by variational scalar values. If parameter ISW(23) is greater than zero, this parameter applies to all sources in the problem run. If parameter ISW(23) equals zero, this parameter is read by the program for each source for which the parameter QFLG is greater than zero. If both parameters ISW(23) and

Gravitational Settling Category Parameters	
QTK Cont.	QFLG equal zero for all sources, this parameter is not read by the program. This parameter is an array which contains the source emission rate scalars used to multiply the average emission rate of a (all) source(s). The format in which the scalar values are entered depends on the value of either parameter QFLG or ISW(23) (whichever parameter is applicable). If this value equals "1", enter four seasonal scalars in the order of Winter, Spring, Summer, and Fall. If the QFLG (or ISW(23)) parameter has a value of "2", enter 12 monthly scalar values beginning with January and ending with December. If the value equals "3", enter 24 scalar values for each hour of the day beginning with the first hour and ending with the twenty-fourth hour. If the value equals "4", enter six sets of scalar values for the six wind speed categories for a total of 36 scalar values. Each of the six sets of scalar values represents a Pasquill stability beginning with category A and ending with category F. Each set is started on a new card image. If the value equals "5", four sets of scalar values are entered where each set contains 24 hourly values (analogous to a value equal to "3" option) for a total of 96 scalar values. The four sets of scalar values represent the four seasons in the order of Winter, Spring, Summer, and Fall. Each set is started on a new card image.

f. Hourly Meteorological Data. These data may be entered in one of two formats (governed by the value entered in parameter ISW(19)). One format is that generated by the preprocessor program. This format usually resides on magnetic tape where the tape device is externally associated with the logical unit specified by parameter IMET. All hourly data required by the program are contained on the tape. The other format is card image. The following data are required for each hour only when the card image format is chosen by the user. Recall that with the card image method, the calm winds processing routine and regulatory default options cannot be used.

Parameter Name	
JDAY	Julian Day -- This parameter specifies the Julian Day of this day of meteorological data. This parameter is read by the program for only the first hour of data for each day. This parameter is ignored for the second and successive hours of

Parameter Name	
JDAY Cont.	each day of data. This parameter is used by the program to determine the month or season if required by other program options. The default value equals "1" (Julian Day 1).
AFV	Wind Flow Vector -- This parameter specifies the direction (degrees) toward which the wind is blowing.
AWS	Wind Speed -- This parameter specifies the mean wind speed (meters/second) measured at the reference height specified in parameter ZR.
Gravitational Settling Categories Parameter	
HLH	Mixing Height -- This parameter specifies the height of the top of the surface mixing layer (meters).
TEMP	Ambient Air Temperature -- This parameter specifies the ambient air temperature (degrees Kelvin).
DTHDZ	Vertical Potential Temperature Gradient (Optional) -- This parameter specifies the vertical potential temperature gradient (degrees Kelvin/meter) for a given hour. The value for this parameter is used by the program only if parameter ISW(22) equals "3".
IST	Pasquill Stability Category -- This parameter specifies the Pasquill stability category. A value of "1" equals category A, "2" equals B, "3" equals C, etc.
P	Wind Profile Exponent (Optional) -- This parameter specifies the wind profile exponent for a given hour. The value for this parameter is used by the program only if parameter ISW(21) equals "3".
DECAY	Decay Coefficient -- This parameter specifies the decay coefficient (seconds^{-1}) for chemical or other removal processes for a given hour. This parameter overrides any value entered in parameter DECAY described earlier in Section 3.1.2.b. If the regulatory default option is chosen (ISW(28) = 1) and SO_2 is modeled in an Urban mode, the program assigns a decay coefficient corresponding to a half life of four hours. Otherwise, pollutant decay is not considered.

3.1.3 Output Information

The ISCST program generates six categories of program output. Each category is optional to the user. That is, the user controls what output the program generates for a given problem run. In the following paragraphs, each category of output is related to the input parameter that controls the output category. All program output are printed except for the output to disc file.

a. Input Parameter Output. The user may desire to see all input parameters used by the program. If input parameter ISW(6) equals "1", the program will print all program control input parameters, meteorological-related and information constants, receptor data and source data, additionally, if parameter ISW(6) equals "2", the program will also print all hourly meteorological data processed by the program for a given problem run.

b. Daily Concentration (Deposition) Output. This category of output prints calculated values of average concentration or total deposition for each day of meteorological data processed by the program for a given problem run. For each day, tables consisting of average concentration or total deposition values at each receptor point are printed for all combinations of user-defined time periods and source groups. For example, suppose combinations of 1-, 3-, and 24-hour time periods and five source groups (NGROUP equals "5") are specified and input parameter IPERD equals "0". Thirty-three tables would be generated by all time period intervals (twenty-four 1-hour tables, eight 3-hour tables, and one 24-hour table) for a total of 165 tables for all source groups for each day of meteorological data. Input parameters ISW(7) through ISW(14) and IPERD specify the time periods and time period interval, respectively, for which average concentration or total deposition values are printed. The source group combinations are specified by input parameters

NGROUP, NSOGRP, and IDSOR. Input parameter ISW(16) controls the employment of this output category.

c. "N"-Day Concentration (Deposition) Output. This category prints the average concentration or total deposition calculated over the number of days ("N") of meteorological data processed by a given problem run. Tables consisting of average concentration or total deposition values at each receptor point are printed for all source group combinations defined by the user with input parameters NGROUP, NSOGRP, and IDSOR. Input parameter ISW(15) specifies the use of this output category.

d. Highest, Second-Highest and Third-Highest Concentration (Deposition) Output. This category prints tables of the highest, second-highest and third-highest average concentration or total deposition values calculated at each receptor point. Tables are produced for all user-defined combinations of time periods and source groups. For example, suppose 3- and 8-hour time periods and ten source groups (NGROUP equals "10") are specified. Thirty-three tables would be produced by all time periods (tables of highest values and tables of second-highest values and tables of third-highest values) for a total of 330 tables for all source groups for the example problem run. Input parameters ISW(7) through ISW(14), and NGROUP, NOSGRP, and IDSOR provide user control of the desired time periods and source groups, respectively. The employment of this output category is controlled by input parameter ISW(17).

e. Maximum 50 Concentration (Deposition Output). This category produces tables of the maximum 50 average concentration or total deposition values calculated for the problem run. Each table prints the maximum 50 values including when and at which receptor each value occurred. Tables are printed for all user-defined combinations of time periods and source groups which are specified by input parameters ISW(7) through ISW(14), and NGROUP, NOSGRP, and IDSOR, respectively. Input parameter ISW(18) controls the use of this output category.

f. Concentration (Deposition) Output to Disc File. This category writes the results of average concentration or total deposition calculations to a file whose device is linked to the program through input parameter ITAP. If ISW(5) equals "1", the program writes records of the average concentration or total deposition values for all user-defined combinations of time periods and source groups for each day of meteorological data processed by the program. Each record includes the average concentration or total deposition values calculated at each receptor point. Also, all concentration or deposition values generated by the "N"-day output option (see category c above) are written to disc only if the "N"-day output option (ISW(15)) is exercised by the user.

An illustration of each of the above print output categories is shown in Section 3.2.4. Also discussed is the order in which the tables and file records are generated for each output category.

3.2 User's Instructions for the ISCST Program

3.2.1 Program Description

The ISC short-term (ISCST) program is designed to use hourly meteorological data to calculate ground-level concentration or deposition values produced by emissions from multiple stack, volume, and area sources. The receptors at which concentration or deposition values are calculated may be defined on a (X, Y) right-handed Cartesian coordinate system grid or an (r, θ) polar coordinate system grid. The polar coordinate system defines 360 degrees as north (positive Y-axis), 90 degrees as east (positive X-axis), 180 degrees as south and 270 degrees as west. Discrete or arbitrarily placed receptors may also be defined by the user using either type of coordinate system. When a polar coordinate system is used it should be remembered that an origin at (X=0, Y=0) is assumed. This program also has the user option of assigning elevations above mean sea level to each source and receptor. The stack, volume or area sources may be individually located anywhere, but must be referenced using a Cartesian coordinate system relative to the origin of the receptor coordinate system.

Average concentration or total deposition values may be calculated for 1-, 2-, 3-, 4-, 6-, 8-, 12-, or 24-hour time periods. "N"-day average concentration or total deposition values for the total number of days of meteorological data processed by the program may also be computed for each receptor. Average concentration or total deposition values may be printed for source groups, where a source group consists of any user-defined combination of sources.

The ISCST program accepts hourly meteorological input data in either of two options. One option reads hourly meteorological data from a disc file, magnetic tape unit or other similar external input device. These data are read in a format compatible with the meteorological data format generated by the preprocessor program. The other option reads hourly meteorological data from cards in a card image format. Note, the regulatory default option and the calm processing option are not available when meteorological data is input with cards.

The ISCST program produces several categories of output of calculated concentration or deposition values. All categories of output are optional to the user. Average concentration or total deposition values may be printed for all receptors for all combinations of time intervals and source groups for any number of days of meteorological data. The average concentration or total deposition values calculated over an "N"-day period may be printed for all source groups defined by the user. Also, the highest, second-highest and third-highest average concentration or total deposition values calculated at each receptor for all combinations of time periods and source groups may be printed. The maximum 50 calculated average concentration or total deposition values may also be printed for all combinations of time periods and source groups defined by the user. The program may also generate an output tape file consisting of all calculated concentration or deposition values for each receptor for each user-defined combination of time periods and source groups for each day of meteorological data processed by the program. Additionally, all average concentration or total deposition values calculated over an "N"-day period may be written to the output tape file for all user-defined source groups.

The ISCST program is written in FORTRAN 77. Its design assumes that 4 Hollerith characters can be stored in a computer word. The basic program requires about 32,000 UNIVAC 1100 Series 36-bit words. Another 43,500 words of data storage are currently allocated for a total of 75,500 computer words. With this current allotment of executable storage, the program may be run with up to approximately 400 receptors and 100 sources. The card reader or input device to this program is referenced as FORTRAN logical unit 5 and the printer or output device as logical unit 6. The ISCST program is composed of a main program (ISCST), fifteen subroutines (INCHK, MODEL, DYOUT, MAXOT, MAX50, VERT, SIGMAZ, ERFX, URBNYZ, XVY, XVZ, URBBAR, AVCALM, NMCALM, and MPR1) and a BLOCK DATA subprogram (BLOCK). The source codes for all of these routines are listed in Appendix A. Appendix E contains a logic flow description of the ISCST program.

3.2.2 Data Deck Setup

The card input data required by the ISCST program depends on the program options desired by the user. The card input data may be partitioned into seven major groups of card input. Figure 3-1 illustrates the input deck setup. The seven card input deck groups are itemized below:

(1) Title Card (1 card)

(2) Program Control Cards (2 cards)

(3) Receptor Cards

(4) Source Group Data Cards (optional, required only if NGROUP > 0)

(5) Meteorological-Related and Model Constants Cards

(6) Source Data Cards

(7) Hourly Meteorological Data Cards (optional, required only if ISW(19) = 2)

Example input data for the ISCST program are presented in Appendix C. A description of the input format and contents of each of the seven card groups is provided below in Section 3.2.3.a.

3.2.3 Input Data Description

Section 3.1.2 provides a summary description of all input data requirements of the ISCST program. This section provides the user with the format and order in which the program requires the input data. The input parameter names used in this section correspond to those used in Section 3.1.2. Two forms of input data are read by the program. One form is card image input data (80 characters per record) in which all required input data may be entered. The other form is magnetic tape which contains hourly meteorological data in a format generated by the preprocessor program. Both forms are discussed below.

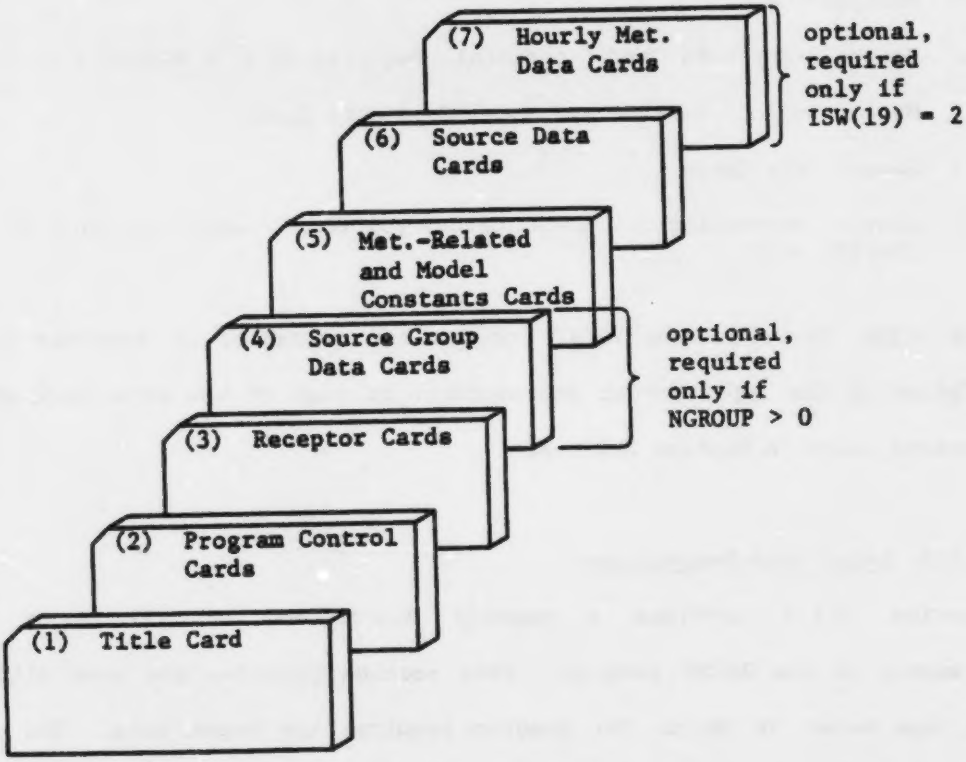
(7) Hourly Met. Data Cards
optional, required only if ISW(19) = 2
(6) Source Data Cards
(5) Met.-Related and Model Constants Cards
(4) Source Group Data Cards
optional, required only if NGROUP > 0
(3) Receptor Cards
(2) Program Control Cards
(1) Title Card

FIGURE 3-1. Input data deck setup for the ISCST program.

a. Card Input Requirements. The ISCST program reads all card image input data in a fixed-field format with the use of FORTRAN "A", "I", "F", AND "E" editing codes. The card input data are partitioned into seven card groups which are discussed in Section 3.2.2.b and shown in Figure 3-1. The input parameters contained in Card Groups (2) and (4) correspond with those described in category "a" of Section 3.1.2. Moreover, Card Groups (1) and (5) correspond with categories "b" and "c", Group (3) with category "d", Group (6) with category "e" and Group (7) with category "f". Table 3-4 is a list of all card image input data which may be entered. For each input parameter, Table 3-4 provides the Card Group (and the card number within the Card Group, if possible), parameter name, card columns within which the value of the input parameter must reside, FORTRAN editing code and a brief description which includes default values or maximum values allowed, if applicable. The order in which the input parameters are listed in Table 3-4 is the order in which the ISCST program reads the input parameters. The user should note that many card input parameters and even entire Card Groups are ignored or not read by the program, depending on the options chosen by the user.

Card Groups (1) and (2) consist of a total of three cards. Card Group (1) consists of one card and contains the parameter TITLE. Card Group (2) consists of the "ISW" array which contains most of the program's control or specification parameters. Also contained in Card Group (2) are parameters which specify the number of sources (NSOURC), the size of the receptor grid (NXPNTS and NYPNTS), the number of discrete receptors (NXWYPT) and the number of source group combinations (NGROUP). The maximum number of sources and receptors is not limited to individual parameters but is a function of four parameters. This function can be described as:

$$\begin{aligned} \mathrm{LIMIT} \geq\ & \mathrm{NPNTS} \bullet (\mathrm{NAVG} \bullet \mathrm{NGROUP} + 2) + \mathrm{NXPNTS} + \mathrm{NYPNTS} \\ & + 2 \bullet \mathrm{NXWYPT} + 215 \bullet \mathrm{NSOURC} + A + B + C + D \end{aligned} \tag{3-1}$$

TABLE 3-4

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
1	TITLE	1-60	15A4	60-character heading label
2, 1	ISW(1)	1-2	I2	1 = calculate concentration 2 = calculate deposition Default assumes 1
2, 1	ISW(2)	3-4	I2	1 = Cartesian coordinate receptor grid system 2 = polar coordinate receptor grid system 3 = program generates Cartesian coordinate grid 4 = program generates polar coordinate grid direction radials Default assumes 1
2, 1	ISW(3)	5-6	I2	1 = discrete receptors referenced with Cartesian coordinate system 2 = discrete receptors referenced with polar coordinate system Default assumes 1
2, 1	ISW(4)	7-8	I2	0 = no receptor terrain elevations are input 1 = program reads receptor terrain elevations -1 = program reads elevations in meters Default assumes 0
2, 1	ISW(5)	9-10	I2	0 = no output file containing concentration or deposition values is written 1 = concentration or deposition values are written on logical unit ITAP Default assumes 0

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(6)	11-12	I2	0 = no input data are printed 1 = print all input data except hourly meteorological data 2 = same as 1 but hourly meteorological data are also printed Default assumes 0
2, 1	ISW(7)	13-14	I2	0 = no 1-hour time periods 1 = 1-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(8)	15-16	I2	0 = no 2-hour time periods 1 = 2-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(9)	17-18	I2	0 = no 3-hour time periods 1 = 3-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(10)	19-20	I2	0 = no 4-hour time periods 1 = 4-hour average concentration or total deposition calculated Default assumes 0

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(11)	21-22	I2	0 = no 6-hour time periods 1 = 6-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(12)	23-24	I2	0 = no 8-hour time periods 1 = 8-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(13)	25-26	I2	0 = no 12-hour time periods 1 = 12-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(14)	27-28	I2	0 = no 24-hour time periods 1 = 24-hour average concentration or total deposition calculated Default assumes 0
2, 1	ISW(15)	29-30	I2	0 = print no daily "N"-day output tables 1 = print "N"-day average concentration or total deposition output tables Default assumes 0
2, 1	ISW(16)	31-32	I2	0 = print no daily time period tables 1 = print daily average concentration or total deposition tables for each time period and source group for each day of meteorological data Default assumes 0

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE
(FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(17)	33-34	I2	0 = print no highest and second-highest tables 1 = print highest and second highest average concentration or total deposition calculated at each receptor for each time period and source group 2 = print highest, second highest, and third highest tables Default assumes 0
2, 1	ISW(18)	35-36	I2	0 = print no maximum 50 tables 1 = print the maximum 50 average concentration or total deposition values calculated for each time period and source group Default assumes 0
2,1	ISW(19)	37-38	I2	1 = hourly meteorological data is read from logical unit IMET in a preprocessed format 2 = hourly meteorological data is read from cards Default assumes 1
2, 1	ISW(20)	39-40	I2	0 = Rural Mode Option 1 = Urban Mode-1 Option 2 = Urban Mode-2 Option 3 = Urban Mode-3 Option Default assumes 0

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(21)	41-42	I2	1 = program provides default wind profile exponent values 2 = user enters 36 wind profile exponents for 6 wind speed and 6 stability categories in Card Group 5 below 3 = user enters hourly wind profile exponents in Card Group 7 below Default assumes 1 This parameter is set to 1 when the regulatory default option ISW(28)=1.
2, 1	ISW(22)	43-44	I2	1 = program provides default vertical potential temperature gradient values 2 = user enters 36 vertical potential temperature gradients for 6 wind speed and 6 stability categories 3 = user enters hourly vertical potential temperature gradients in Card Group 7 below Default assumes 1 This parameter is set to 1 when the regulatory default option ISW(28)=1.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE
(FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(23)	45-46	I2	0 = emission rates for all source do not vary 1 = emission rates vary seasonally for all sources 2 = emission rates vary monthly for all sources 3 = emission rates vary each hour per day for all sources 4 = emission rates vary by wind speed and stability category for all sources 5 = emission rates vary seasonally and each hour per day Default assumes 0. A zero value entered for this parameter allows the user to vary emission rates for individual sources by the use of input parameter QFLG.
2, 1	ISW(24)	47-48	I2	1 = program uses final plume rise for all receptor locations 2 = program computes plume rise as a function of the receptor location Default assumes 1 This parameter is set to 1 when the regulatory default option ISW(28)=1.
2, 1	ISW(25)	49-50	I2	1 = physical stack heights are not modified to account for downwash 2 = physical stack heights are modified to account for stack downwash Default assumes 1 This parameter is set to 2 when the regulatory default option ISW(28)=1.
2, 1	ISW(26)	51-52	I2	1 = program uses buoyancy-induced dispersion 2 = program ignores buoyancy-induced dispersion

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 1	ISW(27)	53-54	I2	1 = program uses a calm processing routine to calculate concentrations during calm periods 2 = program does not use a calm processing routine This parameter is set to 1 when the regulatory default option ISW(28)=1 and meteorology is read from tape (ISW(19)=1.
2, 1	ISW(28)	55-56	I2	1 = program sets the regulatory default features. 2 = program does not set the regulatory default features.
2, 1	ISW(29)	57-58	I2	1 = program assumes SO_2 is being modelled 2 = program assumes pollutant other than SO_2 is being modelled
2, 1	ISW(30)	59-60	I2	1 = program uses an input debug mode 2 = program does not use an input debug mode.
2, 2	NSOURC*	1-6	I6	Number of sources
2, 2	NXPNTS*	7-12	I6	Number of grid points in the X-axis or number of ranges (rings) for the receptor grid. A zero value implies no receptor grid
2, 2	NYPNTS*	13-18	I6	Number of grid points in the Y-axis or number of direction radials for the receptor grid. A zero value implies no receptor grid
2, 2	NXWYPT*	19-24	I6	Number of discrete receptor points. A zero value implies no discrete receptor points

*See Equation (3-1) for the maximum value allowed by the program for this input parameter.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2, 2	NGROUP	25-30	I6	Number of source group combinations. A zero value assumes one source group which consists of all sources. Maximum number = 150
2, 2	IPERD	31-36	I6	Print "N"th time interval only for all time periods specified for daily table output. Enter "N" in this parameter. Default assumes all intervals for each desired time period are printed. This parameter is ignored if ISW(16) = 0
2, 2	NHOURS	37-42	I6	Enter number of hours per day of meteorological data. This parameter is ignored if ISW(19) = 1
2, 2	NDAYS	43-48	I6	Enter number of days of meteorological data. This parameter is ignored if ISW(19) = 1
3, 1	GRIDX	1-80	8F10.0	This parameter is not read if NXPNTS or NYPNTS equals 0. Enter NXPNTS X-axis (ISW(2) = 1) or NXPNTS range (ISW(2) = 2 or 4) receptor grid locations (meters). If ISW(2) = 3, enter the starting X-axis grid location in columns 1-10 and the incremental value in columns 11-20 (meters)

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
3, 2	GRIDY	1-80	8F10.0	This parameter is not read if NXPNTS or NYPNTS equals 0. Enter NXPNTS Y-axis (ISW(2) = 1) receptor grid locations (meters) or NYPNTS direction radial (ISW(2) = 2) locations in integer degrees within the range of 1 to 360 degrees. If ISW(2) = 3, enter the starting axis grid location (meters) in columns 1-10 and the incremental value in columns 11-20 (meters). If the ISW(2) = 4, enter the starting direction radial location in columns 1-10 and the incremental value in columns 11-20. Enter values which generate integer directions within the range of 1 to 360 degrees
3, 3	GRIDZ (Non-discrete)	1-80	8F10.0	This parameter, which is an array defining receptor elevations, is not read if ISW(4) = 0 or NXPNTS = 0 or NYPNTS = 0. Receptor elevation Z_{ij} corresponds to the i^{th} X coordinate (range) and j^{th} Y coordinate (direction radial). Begin with Z_{11} and enter NXPNTS values (Z_{11}, Z_{21}, Z_{31}, ...). Then, starting with a new card image, enter NXPNTS values (Z_{12}, Z_{22}, Z_{32}, ...). Continue until all regular receptor elevations have been entered.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
3, 4	XDIS, YDIS, GRIDZ (Discrete)	1-30	3F10.0	These parameters are not read if NXWYPT = 0. Each record contains the information required for 1 discrete receptor. XDIS is the X-axis (ISW(3) = 1) or range (ISW(3) = 2) discrete receptor location (meters). YDIS is the Y-axis (ISW(3) = 1) discrete receptor location (meters) or direction (ISW(3) = 2) of the discrete receptor (degrees). GRIDZ is the discrete receptor elevation. If terrain elevations are not desired, leave the last entry on each card blank.
4*, 1	NSOGRP	1-80	20I4	Enter the number of source identification numbers required to define a source group for each source group combination. Enter NGROUP values. A maximum of 150 values may be entered.
4*, 2	IDSOR	1-78	13I6	Enter the source identification numbers used to define a source group for each source group combination. A minus sign preceding a source identification number implies inclusive summing from the previous source number entered to the source with the minus sign. A maximum of 200 values may be entered.
5, 1-6	PDEF	1-60	6F10.0	This parameter is read only if ISW(21) = 2 and ISW(28) = 2. Enter 36 wind profile exponents. For each of the six Pasquill stability categories, enter 6 values per card for each of the 6 wind speed categories

*This card is not read if parameter NGROUP equals 0.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
5, 7-12	DTHDEF	1-60	6F10.0	This parameter is read only if ISW(22) = 2 and ISW(28) = 2. Enter 36 vertical potential temperature gradients (degrees Kelvin/meter). For each of the six Pasquill stability categories, enter 6 values per card for each of the 6 wind speed categories
5, 13	ZR	1-10	F10.0	Enter the wind speed reference height z_1 (meters). Default assumes 10.0 meters
5, 13	UCATS	11-60	5F10.0	Enter the upper bound of the first through fifth wind speed categories (meters/second). Default assumes 1.54, 3.09, 5.14, 8.23 and 10.8 meters per second
5, 14	TK	1-8	E8.0	Enter the source emission rate conversion factor in order to convert the emission rate units. Default assumes 1.0 x 10^6 for concentration and 1.0 for deposition
5, 14	DECAY	9-16	F8.0	This parameter is ignored if ISW(19) = 2. Enter the decay coefficient (seconds^{-1}) for chemical depletion of a pollutant. Default assumes no decay
5, 14	IQUN	17-28	3A4	A 12-characer label identifying the emission rate units of all sources. Default assumes (grams/second) for concentration and (grams) for deposition. Units of per square meter are automatically included for area sources

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE
(FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
5, 14	ICHIUN	29-56	7A4	A 28-character label identifying the units of concentration or deposition. Default assumes (micrograms/cubic meter) for concentration and (grams/square meter) for deposition
5, 14	IMET	57-58	I2	FORTRAN logical unit number of hourly meteorological data. Default assumes "9" if ISW(19) = 1 and "5" (or current read unit) if ISW(19) = 2
5, 14	ITAP	59-60	I2	FORTRAN logical unit number of concentration or deposition output file. Default assumes "3"
5, 15-19	IDAY	1-80	80I1	This parameter is not read if ISW(19) = 2. This parameter consists of an array of 366 entries where each entry corresponds to the 366 Julian Days in a year. An entry set to "1" indicates that the corresponding Julian Day will be processed by the program. For example, if IDAY(140) = 1, then Julian Day 140 will be processed by the program. Default assumes 0 for all days
5, 20	ISS	1-6	I6	This parameter is not read if ISW(19) = 2. Enter the surface station number of the hourly meteorological data. This number must match the station number read from the meteorological tape
5, 20	ISY	7-12	I6	This parameter is not read if ISW(19) = 2. Enter the year (last two digits only) of the surface station meteorological data. The year must match the corresponding year read from the meteorological tape

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
5, 20	IUS	13-18	I6	This parameter is not read if ISW(19) = 2. Enter the upper air station number of the hourly meteorological data. The number must match the station number read from the meteorological tape
5, 20	IUY	19-24	I6	This parameter is not read if ISW(19) = 2. Enter the year (last two digits only) of the upper air station meteorological data. The year must match the corresponding year read from the meteorological tape
6, 1*	NSO	1-5	I5	Enter a unique source identification number for the problem run. Must be a positive integer
6, 1*	ITYPE	6	I1	0 = stack-type source 1 = volume-type source 2 = area-type source
6, 1*	WAKE	7	I1	This parameter pertains only to stack-type sources with building wake effects. If 0 is entered or left blank, an "upper bound" concentration or deposition is calculated. If 1 is entered, a "lower bound" concentration or deposition is calculated (see Section 2.4.1.1.d)
6, 1*	NVS	8-9	I2	Enter the number of gravitational settling categories. Maximum number allows = 20. Default assumes 0.

*This card is repeated for each source (NSOURC times).

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE
(FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
6, 1*	QFLG	10	I1	This parameter is ignored if ISW(23) > 0. Enter emission rate variation indicator. See input parameter ISW(23) for options. Default assumes 0.
6, 1*	Q	11-18	F8.0	Enter emission rate. For concentration and type 0 and 1 sources, units are mass per time and for type 2 sources, units are mass per square meter per time. For deposition and type 0 and 1 sources, units are in mass and for type 2 source units are in mass per square meter.
6, 1*	XS	19-25	F7.0	X-coordinate (east-west location) in meters of the center of a stack or volume source and the southwest corner of an area source
6, 1*	YS	26-32	F7.0	Y-coordinate (north-south location) in meters of the center of a stack or volume source and the southwest corner of an area source
6, 1*	ZS	33-38	F6.0	Elevation of the source at the source base (meters above mean sea level)
6, 1*	HS	39-44	F6.0	Enter source height (meters). For type 0 sources, enter stack height; for type 1 sources, enter height at the center of volume source; for type 2 sources, enter the effective emission height.

*This card is repeated for each source (NSOURC times).

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE
(FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
6, 1*	TS	45-50	F6.0	For type 0 sources, enter the stack exit temperature (degrees Kelvin); for type 1 sources, enter the initial vertical dimension σ_{zo} in meters
6, 1*	VS	51-56	F6.0	For type 0 sources, enter the stack exit velocity (meters per second); for type 1 sources, enter the initial horizontal dimension σ_{yo} in meters; for type 2 sources, enter the width (meters) of a square area source.
6, 1*	D	57-62	F6.0	For type 0 sources, enter the inner stack diameter (meters)
6, 1*	HB**	63-68	F6.0	For type 0 sources, enter the height (meters) of a building adjacent to this stack source
6, 1*	HL**	69-74	F6.0	For type 0 sources, enter the length (meters) of a building adjacent to this stack source
6, 1*	HW**	75-80	F6.0	For type 0 sources, enter the width (meters) of a building adjacent to this stack source
6, 2*	PHI	1-80	8F10.0	This parameter is not read if NVS equals zero from card 1 for a given source. Enter the mass fraction of particulates for each gravitational settling category. Enter NVS values

*This card is repeated for each source (NSOURC times).

**If non-zero values are entered for parameters HB or HL and HW, the program automatically uses the building wake effects option (see Section 2.4.1.1.d). However, if HB, HL, and HW are not punched or are equal to "0," wake effects for the respective source are not considered.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
6, 3*	VSN	1-80	8F10.0	This parameter is not read if NVS equals zero from card 1 for a given source. Enter the gravitational settling velocity (meters per second) for each gravitational settling category. Enter NVS values
6, 4*	GAMMA	1-80	8F10.0	This parameter is not read if NVS equals zero from card 1 for a given source. Enter the surface reflection coefficient for each gravitational settling category. Enter NVS values
6, 5**	QTK	1-80	8F10.0	Enter the source emission rate scalars in a manner depending on the value of ISW(23) or QFLG (whichever parameter is available). If ISW(23) or QFLG = 1 enter 4 seasonal scalars in the order of winter, spring, summer, and fall (1 card); if = 2, enter 12 monthly scalars beginning with January and ending with December (2 cards); if = 3, enter 24 scalars for each hour of the day (3 cards); if = 4, enter 6 scalars per card for each wind speed category and 6 cards for each of the six Pasquill stability categories (A-F) (6 cards); and if = 5, enter 24 hourly scalars for each of the four seasons (12 cards)

*This card group is repeated for each source (NSOURC times)

**This card is not read if ISW(23) = 0 and QFLG = 0 for all sources. Otherwise, if ISW(23) >0 then this card is read once; if ISW(23) = 0, this card is read for each source for which QFLG >0.

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
7*, 1**	JDAY	6-8	I3	Enter the Julian Day of this day of hourly meteorological data. This is used to compute the season or month if required for any sources which have variational emission rates
7*, 1**	AFV	9-16	F8.0	Enter the direction (degrees) toward which the wind is blowing. This value is also used as the random wind flow vector by the model
7*, 1**	AWS	17-24	F8.0	Enter the mean wind speed (meters per second) measured at reference height z_1
7*, 1**	HLH	25-32	F8.0	Enter the height of the top of the surface mixing layer (meters).
7*, 1**	TEMP	33-40	F8.0	Enter the ambient air temperature (degrees Kelvin)
7*, 1**	DTHDZ	41-48	F8.0	This parameter is read only if ISW(22) = 3. Enter the vertical potential temperature gradient (degrees Kelvin per meter)
7*, 1**	IST	56	I1	Enter the Pasquill stability category (1 = A, 2 = B, 3 = C, etc.)

*This card group is not read if ISW(19) = 1. If ISW(19) = 2, this card group is repeated NDAYS times.

**This card is repeated for each hour of the day (NHOURS times).

TABLE 3-4
(Continued)

ISCST PROGRAM CARD INPUT PARAMETERS, FORTRAN EDIT CODE (FORMAT) AND DESCRIPTION

Card Group, Card Number	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
7*, 1**	P	57-64	F8.0	This parameter is read only if ISW(21) = 3. Enter the wind profile exponent
7*, 1**	DECAY	65-72	F8.0	Enter the decay coefficient (seconds^{-1}) for chemical removal of a pollutant for this hour. Default or "0" assumes no decay. This value overrides any value entered in parameter DECAY in Card Group 5. When the regulatory default option ISW(28)=1, for SO_2 and urban mode, this parameter is set to a value corresponding to a half-life of 4-hours. In all other cases when ISW(28)=1, DECAY=0.

*This card group is not read if ISW(19) = 1. If ISW(19) = 2, this card group is repeated NDAYS times.

**This card is repeated for each hour of the day (NHOURS times).

where:

NSOURC = number of input sources (see card columns 1-6 of the second card of Card Group (2))

NXPNTS = number of X points or ranges in the receptor grid (see card columns 7-12 of the second card of Card Group (2))

NYPNTS = number of Y points or direction radials in the receptor grid (see card columns 13-18 of the second card of Card Group (2))

NXWYPT = number of discrete receptors (see card columns 19-24 of the second card of Card Group (2))

NPNTS = NXPNTS • NYPNTS + NXWYPT (total number of receptors)

NAVG = number of time periods. This equals the number of time period parameters (ISW(7) through ISW(14) in the first card of Card Group (2)) set to "1"

NGROUP = number of source group combinations (see card columns 25-30 of the second card of Card Group (2)). For the purpose of computing the required data storage for a problem run, assume NGROUP equals "1" in Equation (3-1) if NGROUP equals "0" in Card Group (2)

A = NPNTS • NGROUP if ISW(15) equals "1" in the first card of Card Group (2); otherwise A equals "0"

B = 4 • NAVG • NPNTS • NGROUP if ISW(17) equals "1" in the first card of Card Group (2); otherwise B equals "0"

C = 201 • NAVG • NGROUP if ISW(18) equals "1" in the first card of Card Group (2); otherwise C equals "0"

D = 201 • NAVG • NGROUP if ISW(18) equals "1" in the first card of Card Group (2); otherwise D equals "0"

and

LIMIT = 43,500. This is the current data storage allocation of the program (consult Section 3.2.7 for modification of this value)

Card Group (3) consists of parameters which contain the receptor location information. If the user chooses not to define a receptor grid (either NXPNTS or NYPNTS = "0"), the program does not read parameters GRIDX, GRIDY and GRIDZ (regular). Likewise, parameters XDIS, YDIS and GRIDZ (discrete) are not read by the program if the user chooses not to specify any discrete receptors (NXWYPT = "0"). If ISW(4) = 0 both GRIDZ (regular) and GRIDZ (discrete) are not entered. All regular receptor information is read before discrete receptor information. In addition, one discrete receptor card is read for each discrete receptor. This format is described in Table 3-4 and Section 3.1.2.d.

Card Group (4) contains the parameters which define what sources constitute each source group combination. This Card Group is not read by the program if NGROUP equals "0" in the second card of Group (2). Parameter NSOGRP reads up to 20 integer values per card in 4-column fields. Parameter IDSOR reads up to 13 integer values per card in 6-column fields.

Card Group (5) consists of meteorological-related parameters which remain constant once they are set, and identification labels and model constants. The first parameter in this Card Group (PDEF) consists of six cards, and is read by the program only if ISW(21) equals "2" and ISW(28) = "2" in Card Group (2). Likewise, the second parameter (DTHDEF) consists of six cards, and is read by the program only if ISW(22) equals "2" and ISW(28) = "2". The following two cards (cards 13 and 14) are read by the program and contain parameters which have program-provided default values as indicated in Table 3-4. The user should note that the default values of the units conversion factor (TK), the units label for source emission rates (IQUN) and the units label for concentration or deposition (ICHIUN) are compatible. That is, the default mass units of the source emission rates (grams) is scaled by the default conversion value which is compatible with the default mass units of concentration (micrograms) or deposition (grams). Cards 15 through 19 in this Card Group consist of the IDAY parameter. IDAY is not read by the program if ISW(19) equals "2" in Card Group (2). This parameter is an array where each column on the 80-column card image for each card represents a Julian Day. For example, to indicate that Julian Day 140 of the hourly meteorological data is to be processed by the program, IDAY(140) is set to "1" which is column 60 of the second card of the IDAY parameter. The remaining parameters consist of one card (the 20th possible card of this Card Group) and are not read if ISW(19) equals "2" in Card Group (2).

Card Group (6) contains all source data parameters. Except for the last parameter (card 5) in this Card Group (QTK), this Card Group is repeated for each source input (NSOURC times). The first card of this Card Group consists of the principal parameters used to define the characteristics of a source. Cards 2 to 4 pertain to the gravitational settling categories of particulates (parameters PHI, VSN, and GAMMA) and are read by the program only when parameter NVS in columns 8-9 of the first card is greater than "0" for a given source. If NVS is greater than "0", cards 2 to 4 are read immediately following the first source card for which NVS is greater than "0". It should be noted that cards 2 to 4 of this Card Group may actually consist of more than 3 cards. That is, if NVS is greater than "8", the program will read more than one card for each of the three settling category parameters (PHI, VSN, and GAMMA). Hence, depending on the value of NVS, the program reads no cards, 3 cards, 6 cards, or 9 cards for parameters PHI, VSN, and GAMMA. After the first through fourth cards are read for all sources, card 5 (consisting of the source emission rate scalar array (QTK)) is read, provided one of two options is exercised by the user. That is, either ISW(23) is greater than "0" in Card Group (2) or any number of the QFLG parameter in card 1 of this Card Group are greater than "0" for all input sources. If both ISW(23) and QFLG are equal to "0" for all sources, card 5 of this Card Group is not read by the program. If ISW(23) is greater than "0", card 5 is read once and contains the source emission rate scalars for all sources. Also, the QFLG parameter in card 1 of this Card Group is ignored for all input sources. If ISW(23) equals "0", card 5 is repeated each time a QFLG parameter is greater than "0" for a source. The source emission rate scalars contained in card 5 of this Card Group allow the user to vary emission rates as a function of season*, month*, hour of the day, wind speed and Pasquill stability category, or season and hour of the day. As mentioned in the descriptions of parameter QTK in Table 3-4 and Section 3.1.2.e, the value of ISW(23) or QFLG (whichever is applicable) governs the number and manner in which the source emission rate scalars are entered into parameter QTK. If ISW(23) (or QFLG) equals "1", QTK contains 4 seasonal scalars in the order of Winter, Spring, Summer, and Fall (1 card). If ISW(23) (or QFLG) equals "2", enter 12 monthly scalars beginning with January and ending with December (2 cards). If ISW(23) (or QFLG) equals "3", enter 24 scalars for each hour of the day beginning with hour 1 and ending with hour 24 (3 cards). If ISW(23) (or QFLG) equals "4", enter 6 scalars per card for each wind speed category (1 to 6) and 6 cards for each of the six Pasquill stability categories (A to F) for a total of 36 scalars (6 cards). If ISW(23) (or QFLG) equals "5", enter 24 hourly scalars for each hour and 4 sets for each season (12 cards). Hence, card 5 of this Card Group may actually consist of more than one card depending on the value of ISW(23) (or QFLG).

Card Group (7) contains the hourly meteorological data parameters. This Card Group is not read if ISW(19) equals "1"; instead all hourly meteorological data are read from an input file described in the following paragraph (Section 3.2.3.b). This Card Group is repeated for each day of meteorological data to be processed (NDAYS times). All meteorological data parameters are contained on one card image which is read for each hour per day of meteorological data (NHOURS times).

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*The program determines the season or month based on the Julian Day or month value read from the hourly meteorological data. Consult Table 3-5 for the conversion used by the program of Julian Day to month or season, and month to season.

TABLE 3-5

JULIAN DAY TO MONTH/SEASON OR MONTH TO SEASON CONVERSION CHART FOR LEAP YEARS*

Winter				Spring						Summer						Autumn						Winter	
Jan = 1		Feb = 2		Mar = 3		Apr = 4		May = 5		Jun = 6		Jul = 7		Aug = 8		Sep = 9		Oct = 10		Nov = 11		Dec = 12	
1	1	1	32	1	61	1	92	1	122	1	153	1	183	1	214	1	245	1	275	1	306	1	336
2	2	2	33	2	62	2	93	2	123	2	154	2	184	2	215	2	246	2	276	2	307	2	337
3	3	3	34	3	63	3	94	3	124	3	155	3	185	3	216	3	247	3	277	3	308	3	338
4	4	4	35	4	64	4	95	4	125	4	156	4	186	4	217	4	248	4	278	4	309	4	339
5	5	5	36	5	65	5	96	5	126	5	157	5	187	5	218	5	249	5	279	5	310	5	340
6	6	6	37	6	66	6	97	6	127	6	158	6	188	6	219	6	250	6	280	6	311	6	341
7	7	7	38	7	67	7	98	7	128	7	159	7	189	7	220	7	251	7	281	7	312	7	342
8	8	8	39	8	68	8	99	8	129	8	160	8	190	8	221	8	252	8	282	8	313	8	343
9	9	9	40	9	69	9	100	9	130	9	161	9	191	9	222	9	253	9	283	9	314	9	344
10	10	10	41	10	70	10	101	10	131	10	162	10	192	10	223	10	254	10	284	10	315	10	345
11	11	11	42	11	71	11	102	11	132	11	163	11	193	11	224	11	255	11	285	11	316	11	346
12	12	12	43	12	72	12	103	12	133	12	164	12	194	12	225	12	256	12	286	12	317	12	347
13	13	13	44	13	73	13	104	13	134	13	165	13	195	13	226	13	257	13	287	13	318	13	348
14	14	14	45	14	74	14	105	14	135	14	166	14	196	14	227	14	258	14	288	14	319	14	349
15	15	15	46	15	75	15	106	15	136	15	167	15	197	15	228	15	259	15	289	15	320	15	350
16	16	16	47	16	76	16	107	16	137	16	168	16	198	16	229	16	260	16	290	16	321	16	351
17	17	17	48	17	77	17	108	17	138	17	169	17	199	17	230	17	261	17	291	17	322	17	352
18	18	18	49	18	78	18	109	18	139	18	170	18	200	18	231	18	262	18	292	18	323	18	353
19	19	19	50	19	79	19	110	19	140	19	171	19	201	19	232	19	263	19	293	19	324	19	354
20	20	20	51	20	80	20	111	20	141	20	172	20	202	20	233	20	264	20	294	20	325	20	355
21	21	21	52	21	81	21	112	21	142	21	173	21	203	21	234	21	265	21	295	21	326	21	356
22	22	22	53	22	82	22	113	22	143	22	174	22	204	22	235	22	266	22	296	22	327	22	357
23	23	23	54	23	83	23	114	23	144	23	175	23	205	23	236	23	267	23	297	23	328	23	358
24	24	24	55	24	84	24	115	24	145	24	176	24	206	24	237	24	268	24	298	24	329	24	359
25	25	25	56	25	85	25	116	25	146	25	177	25	207	25	238	25	269	25	299	25	330	25	360
26	26	26	57	26	86	26	117	26	147	26	178	26	208	26	239	26	270	26	300	26	331	26	361
27	27	27	58	27	87	27	118	27	148	27	179	27	209	27	240	27	271	27	301	27	332	27	362
28	28	28	59	28	88	28	119	28	149	28	180	28	210	28	241	28	272	28	302	28	333	28	363
29	29	29	60	29	89	29	120	29	150	29	181	29	211	29	242	29	273	29	303	29	334	29	364
30	30			30	90	30	121	30	151	30	182	30	212	30	243	30	274	30	304	30	335	30	365
31	31			31	91			31	152			31	213	31	244			31	305			31	366

*For non-leap years, subtract 1 from Julian Day numbers corresponding to calendar days after February 28.

b. Disc or Tape Input Requirements. The ISCST program accepts an input file of hourly meteorological data in a format generated by the preprocessor program. Although this file is optional, most problems call for hourly meteorological data in this format. If input parameter ISW(19) equals "1", the program reads hourly meteorology from an input file. If ISW(19) equals "2", the program reads hourly meteorological data in a card image format. The program reads the input file from the FORTRAN logical unit number specified in parameter IMET. The user must provide the surface station number and year, and the upper air station number and year which are specified in parameters ISS, ISY, IUS, and IUY, respectively. The user does not need to know the specific format of the hourly meteorological data contained in the input file. For a description of the specific format of the input tape file, the reader is referred to Table 3-6.

3.2.4 Program Output Data Description

The ISCST program generates several categories of printed output and an optional output file. The following paragraphs describe the format and content of both forms of program output.

a. Printed Output. The ISCST program generates five categories of printed output, four of which are tables of average concentration or total deposition values. All five categories of printed output are optional to the user. That is, the user must indicate which categories are desired to be printed for a particular problem run. The five categories are:

- Input Data (Card and Tape) Listing
- Daily Calculated Average Concentration or Total Deposition Tables
- "N"-Day Calculated Average Concentration or Total Deposition Tables

TABLE 3-6

PREPROCESSOR OUTPUT FILE RECORD DESCRIPTION

Position of Variable Within the Record	Variable Name	FORTRAN Variable Type	
1	IYEAR	INTEGER	Year of record (last two digits)
2	IMONTH	INTEGER	Month
3	DAY1	REAL	Julian Day
4-27	KST	INTEGER	Array of 24 Stability Category Values
28-51	SPEED	REAL	Array of 24 Wind Speed Values (ms^{-1})
52-75	TEMP	REAL	Array of 24 Ambient Temperature Values (°K)
76-99	AFV	REAL	Array of 24 Flow Vector Values (degrees)
100-123	FVR	REAL	Array of 24 Randomized Flow Vectors (degrees)
124-171	HLH	REAL	Array dimensioned 2 by 24 containing 24 rural mixing height values and 24 urban mixing height values (m). The values are stored on the record in groups of two for each hour with the rural mixing height first followed by the urban mixing height for that hour

- Highest, Second-Highest and Third-Highest Calculated Average Concentration or Total Deposition Tables
- Maximum 50 Calculated Average Concentration or Total Deposition Tables

These output categories are all available regardless of the setting of the regulatory default option switch ISW(28). The first line of each page of printed output is a heading used to identify the problem run (see input parameter TITLE in Section 3.2.3.a).

The user may list all input data parameters used by the program for a particular problem run. If input parameter ISW(6) equals "1" (discussed in Section 3.2.3.a), the program lists all program control parameters, meteorological-related constants and identification labels, receptor data and source data. See Figure C-2 in Appendix C for an illustration of the content and format of an input data listing for a typical problem run. The user may also direct the program to print all hourly meteorology processed by the program. If ISW(6) equals "2", the program produces a list of the meteorological data for each day processed as shown in Figure C-3 in Appendix C. Hence, a page is generated for each day of meteorology processed by the program (NDAYS pages if ISW(19) equals "2" or the number of entries set to "1" in the IDAY array if ISW(19) equals "1").

The next category of optional printed output are tables of average concentration or total deposition values calculated for each day ("daily") of meteorology processed by the program. If ISW(16) equals "1", tables are printed for each day for all user-defined combinations of source groups and time periods. As shown in Figure C-5 in Appendix C, each table consists of the calculated average concentration values for all receptors. The heading of the table indicates the day, time period, time period interval* and sources that represent the printed values.

The user may direct the program to print tables of calculated concentration averaged over "N"-days or deposition summed over "N"-days where "N" represents the total number of days of meteorology processed by the program run. If ISW(15) equals "1", tables are printed for all user-defined source groups. As shown in Figure C-6 in Appendix C, each table consists of the calculated concentration for all receptors.

The program may also print tables of the highest, second-highest and third-highest average concentration or total deposition values calculated at each receptor point throughout the duration of the problem run. If ISW(17) equals "1", a table of the highest and a table of the second-highest calculated values are printed for all user-defined combinations of source groups and time periods. Figure C-7 in Appendix C is an illustration of a highest calculated average concentration table. The second-highest table is not shown but is similar in format. If ISW(17) equals "2", a third-highest table is also printed.

The final category of the printed output that may be produced are tables of the maximum 50 calculated average concentration or total deposition values found for the problem run. If ISW(18) equals "1", a table of the 50 maximum values is produced for all user-defined combinations of source groups and time periods. As shown in Figure C-8 in Appendix C, each table consists of a heading and the maximum 50 calculated values. The number of tables of daily average concentration or total deposition values is governed by the number of source groups (specified in parameter NGROUP), time periods (specified in parameters ISW(7) through ISW(14)) and time period intervals (parameter

---

*See Table 3-7 for the hours which define a particular time period interval.

TABLE 3-7

TIME PERIOD INTERVALS AND CORRESPONDING HOURS OF THE DAY

Time Period Interval Number	Time Period							
	1-Hour	2-Hour	3-Hour	4-Hour	6-Hour	8-Hour	12-Hour	24-Hour
1	0-1	0-2	0-3	0-4	0-6	0-8	0-12	0-24
2	1-2	2-4	3-6	4-8	6-12	9-16	12-24	-
3	2-3	4-6	6-9	8-12	12-18	16-24	-	-
4	3-4	6-8	9-12	12-16	18-24	-	-	-
5	4-5	8-10	12-15	16-20	-	-	-	-
6	5-6	10-12	15-18	20-24	-	-	-	-
7	6-7	12-14	18-21	-	-	-	-	-
8	7-8	14-16	21-24	-	-	-	-	-
9	8-9	16-18	-	-	-	-	-	-
10	9-10	18-20	-	-	-	-	-	-
11	10-11	20-22	-	-	-	-	-	-
12	11-12	22-24	-	-	-	-	-	-
13	12-13	-	-	-	-	-	-	-
14	13-14	-	-	-	-	-	-	-
15	14-15	-	-	-	-	-	-	-
16	15-16	-	-	-	-	-	-	-
17	16-17	-	-	-	-	-	-	-
18	17-18	-	-	-	-	-	-	-
19	18-19	-	-	-	-	-	-	-
20	19-20	-	-	-	-	-	-	-
21	20-21	-	-	-	-	-	-	-
22	21-22	-	-	-	-	-	-	-
23	22-23	-	-	-	-	-	-	-
24	23-24	-	-	-	-	-	-	-

IPERD). After all hourly meteorological data have been processed by the program, the "N"-day tables, highest, second-highest and third-highest tables and the maximum 50 tables are alternately printed for each source group for each specified time interval. The number of tables is governed by the number of source groups (NGROUP) and time periods (ISW(7) through ISW(14)) specified.

b. Output File. The ISCST program is capable of generating an output file containing the calculated average concentration or total deposition values based on the selected time periods and source groups. If ISW(5) equals "1", this output file is generated. The user must assign an output file and associate the logical unit number specified in parameter ITAP to the output file (see Section 3.2.3.a).

The output file is written with a FORTRAN unformatted (binary) WRITE statement and consists of constant length records whose lengths equal the total number of receptor points (NPNTS) plus 3 words. Word 1 of each record contains the hour at which the corresponding values were calculated in words 4 to NPNTS +3. Word 2 contains the Julian Day and word 3 contains the source group number. Words 4 through NPNTS + 3 contain the calculated average concentration or total deposition values for all receptors. The values calculated for the receptor grid (if any) are written first followed by the values calculated at the discrete receptors (if any). Starting with the first Y point (direction radial) of the Y-axis (radial) grid, the calculated values are written for the X-axis (ranges) in the same order that receptor locations were entered in parameter GRIDX (see Section 3.2.3.a). For each successive Y-axis (radial), the values are written for the X-axis (ranges). After the calculated values have been written for the receptor grid, the calculated values are written for the discrete points in the order the discrete points were entered in parameters XDIS and YDIS (see Section 3.2.3.a).

The content and number of records produced is governed by the number of source groups (specified in parameter NGROUP) and time periods (specified in parameters ISW(7) through ISW(14)). For each day of meteorological data processed by the program and for each hour, the program generates records of calculated values for all applicable time period intervals for all source groups. For hour one, a 1-hour record of calculated values for source group 1, followed by 1-hour records of calculated values for each remaining source groups are written to the output file. For hour two, a 1-hour and a 2-hour record are written to the output file for each source group. For hour three, a 1-hour and 3-hour record are written to the output file for each source group. For hour four, a 1-hour, 2-hour, and 4-hour record of calculated values are written to the output file for each source group. This format is continued for each hour of the day. For example, if there is one source group and only 24-hour average concentrations are calculated, only one record per day is written to the output file. If ISW(15) equals "1", records of the "N"-day average concentration or total deposition values are additionally written to the output file for all source groups after the program has processed all "N"-days of meteorological data.

3.2.5 Program Run Time, Page and Tape Output Estimates

This section provides the user with equations which estimate the amount of run time required and program output generated for a given problem run. The equations describing the amount of printed output data (in pages) and tape output data (in words) can be quite accurately estimated. The run time estimate is less accurate because of unknowns such as the nature of the hourly meteorology and wake effects. These unknowns may affect the run time estimate significantly for a large problem run.

a. Run Time. The amount of time a problem takes to execute is primarily governed by six factors. These factors are: (1) the number of hours in a day of meteorological data (NHOURS); (2) the number of days of meteorological data processed (NDAYS); (3) the number of sources (NSOURC); (4) the number of source groups (NGROUP); (5) the number of receptor points (NPNTS); and (6) the number of time periods (NAVG). Using these factors, the following equation estimates the run time in minutes:

$$\begin{aligned}\text{No. of Minutes} = C \bullet (\text{NDAYS} + 1) \bullet (1 + \text{NHOURS} \bullet (1 + 0.8\ \text{NSOURC} \\ \bullet (1 + 0.6 \bullet \text{NPNTS} + 0.1 \bullet \text{NGROUP} \bullet \text{NAVG})))\end{aligned} \tag{3-2}$$

where

$$C = 2.1 \bullet 10^{-5}$$

The constant, C, is derived from problem runs made on a UNIVAC 1108 computer and is different for other computers.

b. Page Output. The number of pages of printer output produced by a problem run is primarily controlled by which categories of output are desired by the user. The content of these categories of program print output are discussed in Section 3.2.4.a. Input parameters ISW(6), ISW(15), ISW(16), ISW(17), and ISW(18), discussed in Section 3.2.3.a., control which categories of program print output are produced. Other factors which determine the amount of print output are the number of receptor points, number of source groups, and the number of time periods for which average concentration or total deposition values are computed.

If ISW(6) equals "1", all input data are printed, producing about 5 pages of print output. For source with gravitational settling categories (NVS greater than zero) or variational emission rates (QFLG greater than zero), add one-third of a page per source. If ISW(6) equals "2", all meteorological data processed by the program are printed. Add one page for every day of meteorological data processed.

If ISW(15) equals "1", tables of the "N"-day average concentration or total deposition values are printed. The number of tables printed equals the number of source groups desired by the user (NGROUP). If parameter NGROUP is specified as "0", one table will be printed. The number of pages produced for each "N"-day table is given the following equation:

$$\text{Number of Pages} = (\text{NXPNTS}/9)\ (\text{NYPNTS}/38) + (\text{NXWYPT}/114) \qquad (3\text{-}3)$$

where

NXPNTS = the number of X points on the X-axis grid or the number of grid ranges

NYPNTS = the number of Y points on the Y-axis grid or the number of grid direction radials

NXWYPT = the number of discrete receptor points

Round up any fractional number in each term to the nearest whole number.

If ISW(16) equals "1", tables of average concentration or total deposition for user-defined combinations of source groups and time periods for each day of meteorological data processed by the program are printed. The number of tables produced by this output category for each day is given by the following equation:

$$\begin{aligned}\text{No. of Tables} = \text{NGROUP} \bullet\ & (24/\text{IPERD}) \bullet \text{ISW}(7)\\ & + (12/\text{IPERD}) \bullet \text{ISW}(8) + (8/\text{IPERD}) \bullet \text{ISW}(9)\\ & + (6/\text{IPERD}) \bullet \text{ISW}(10) + (4/\text{IPERD}) \bullet \text{ISW}(11) \qquad (3\text{-}4)\\ & + (3/\text{IPERD}) \bullet \text{ISW}(12) + (2/\text{IPERD}) \bullet \text{ISW}(13)\\ & + (1/\text{IPERD}) \bullet \text{ISW}(14)\end{aligned}$$

where

NGROUP = number of source groups as specified by input parameters NGROUP. If NGROUP is specified as "0", assume a value of "1" for this equation.

IPERD = "N"th time interval for all time periods as specified by input parameter IPERD. Note that if IPERD is not set to "0", the term (j/IPERD) • ISW(i) equals (j) • ISW(i). If IPERD is set greater than "0", the term (j/IPERD) • ISW(i) equals (1) • ISW(i) if (j/IPERD) is greater than or equal to "1"; otherwise, it equals (0) • ISW(i) if (j/IPERD) is less than "1".

ISW(7)- ISW(14) = the corresponding 1-, 2-, 3-, 4-, 6-, 8-, 12-, and 24-hour time periods as specified by input parameters ISW(7) through ISW(14). The "1" or "0" values specified by the user in these parameters are the numeric values used in the equation

The number of pages produced by each table is given in Equation (3-3). Hence, the total number of pages generated by the print output option ISW(16) equals the product of the number of days processed by the program for a problem run, the number of tables printed according to Equation (3-4) and the number of pages produced per table according to Equation (3-3).

If ISW(17) equals "1", tables of the highest and second-highest average concentration or total deposition values found at each receptor are printed for all user-defined combinations of source groups and time periods. If ISW(17) equals "2" tables of highest, second-highest, and third-highest are printed. The number of tables printed equals two or three (depending on ISW(17)) times the number of time periods specified (the number of input parameters ISW(7) through ISW(14) set to "1") multiplied by the number of source groups desired. If no source groups are specified (input parameter NGROUP equals "0"), assume one source group for the purpose of computing the number of tables printed by this option (ISW(17)). The number of pages each table produces is given by the following equation:

$$\text{Number of Pages} = (\text{NXPNTS}/5)\ (\text{NYPNTS}/38) + (\text{NXWYPT}/76) \qquad (3\text{-}5)$$

where NXPNTS, NYPNTS, and NXWYPT are defined following Equation (3). Round up any fractional number in each term to the nearest whole number. Hence, the number of pages printed by this output category equals two or three, times the product of the number of time periods, the number of source groups, and the number of pages produced per table according to Equation (3-5).

If ISW(18) equals "1", tables of the maximum 50 average concentration or total deposition values calculated are printed for all user-defined combinations of source groups and time periods. Because each table printed produces only one page of output, the total number of pages printed by this output category equals the number of time periods specified (the number of input parameters (ISW(7) through ISW(14) set to "1") multiplied by the number of source groups specified. Again, if no source groups are specified (input parameter NGROUP equal to zero), assume one source group.

Thus, the total number of pages of output produced by the program equals the sum of the number of pages produced by each optional print output category desired by the user for a problem run.

c. Output to Disc File. Values of average concentration or total deposition are written by a FORTRAN unformatted WRITE statement to an output file only if parameter ISW(5) equals "1". Otherwise, the program does not generate an output file. It is not practical to discuss the physical amount (length of magnetic tape or number of tracks or sectors of mass storage) generated since this introduces factors which depend on the computer installation. Instead, the number of computer words generated by a problem run is discussed. The user may then equate this number to a physical amount for the particular storage device being used.

The output file is written in records, where the length of each record equals the number of receptor points (NPNTS) plus 3 for a total of NPNTS + 3 computer words for a given problem run. For each day of meteorological data processed, the number of records written to the file is governed by the number of source groups and time periods specified by the user. If we substitute the term "Tables" used in Equation (3-4) with the word, "Records" and set IPERD equal to "0", Equation (3-4) gives the number of records written to the file for each day of meteorological data processed. All variables used to formulate Equation (3-4) maintain the same definition. Hence, the number of records equals the value computed from Equation (3-4) multiplied by the number of days of meteorological data processed by the program for a problem run. Also, if input parameter ISW(15) equals "1", additional records containing "N"-day average concentration or total deposition values are written to the file depending on the number of source groups specified by the input parameter NGROUP. If NGROUP equals "0", assume one source group. Hence, the total number of computer words written to the file equals the number of records generated, multiplied by (NPNTS + 3) computer words per record for a problem run.

3.2.6 Program Diagnostic Messages

The ISCST program prints diagnostic messages when certain conditions occur during a problem run. The diagnostic messages consist of two types. The first type is a table format that informs the user of the conditions found, but does not terminate program execution. The second type is an error message which informs the user of the condition. The run is terminated after the error message is printed.

The diagnostic message in a table format informs the user when a receptor is located within one meter or three building heights (or three effective building widths) of a source. As shown in Figure C-4 in Appendix C, the table lists all source-receptor combinations for which this condition has occurred. The table lists the source number, receptor location, and calculated distance between the corresponding source and receptor. A negative distance value implies that the receptor is located within the dimensions of a volume or area source.

Four types of diagnostic error messages may be printed by the program. If the allocated data storage is not sufficient for the data required by a problem run, an error message is printed (Figure 3-2(a)). An error message is printed if the station numbers or years read from the meteorological data input tape do not match the corresponding station numbers or years specified by the user in parameters ISS, ISY, IUS, IUY (Figure 3-2(b)). If the number of input sources equals "0", an error message is printed (Figure 3-2(c)). Finally, if there are no gravitational settling categories to calculate deposition for any source, an error message is printed as shown in Figure 3-2(d).

3.2.7 Program Modification for Computers Other than UNIVAC 1100 Series Computers

The ISCST program, which is written in FORTRAN 77, provides easy transport and adaption for use on other computers. The program design requires that: (1) at least four Hollerith characters can be stored in one computer word; (2) the computer word lengths of integer and real type variables are the same; and, (3) at least 132 characters per line can be printed on a page with 57 lines per page. The program requires about 75,500 words of executable storage, 32,000 of which consist of the program itself compiled on a UNIVAC 1100 Computer. The size of the compiled program will vary depending on the FORTRAN compiler and computer installation. The remaining 43,500 words consist of data storage used by the program for storing the input data values, intermediate values, and output results of a given problem run.

```
**ERROR** CALCULATED STORAGE ALLOCATION LIMIT EQUALS nnnnnn AND EXCEEDS THE
MAXIMUM STORAGE ALLOCATION LIMIT OF mmmmmm
RUN TERMINATED.
```

(a)

```
***ERROR***MET DATA REQUESTED DOES NOT MATCH MET DATA READ.
'REQUESTED/READ' VALUES ARE:
SURFACE STATION NO. = isisis/jsjsjs YEAR OF SURFACE DATA = iys/jys
UPPER AIR STATION NO. = iuiuiu/jujuju YEAR OF UPPER AIR DATA = iuy/juy
RUN TERMINATED.
```

(b)

```
***ERROR*** NUMBER OF SOURCES TO BE READ EQUALS ZERO.  RUN TERMINATED.
```

(c)

```
***ERROR*** SOURCE NUMBER nnnnn HAS NO GRAVITATIONAL SETTLING CATEGORIES WITH
WHICH TO CALCULATE DEPOSITION.  RUN TERMINATED.
```

(d)

FIGURE 3-2. (a) through (d) show the four types of error messages printed by the ISCST Program. The run is terminated after an error message is printed.

If it is necessary to adjust the current allotment of 43,500 words of data storage, only two FORTRAN statements in the ISCST program need to be modified. The FORTRAN statement with sequence number ISC06980 (in columns 73-80) in the main program allocates the data storage in array QF. Also, the value assigned to the variable LIMIT at sequence number ISC07060 must agree with the value used in array QF.

The program assumes FORTRAN logical unit 5 for the card reader and logical unit 6 for the printer. These logical unit numbers may be modified on sequence numbers ISC07130 and ISC07140 in the main program.

SECTION 4

USER'S INSTRUCTION FOR THE ISC LONG-TERM (ISCLT) MODEL PROGRAM

4.1 Summary of Program Options, Data Requirements and Output

4.1.1 Summary of ISCLT Program Options

The program options of the ISC Dispersion Model long-term computer program ISCLT consist of three general categories:

- Meteorological data input options
- Dispersion-model options
- Output options

Each category is discussed separately below.

a. Meteorological Data Input Options. Table 4-1 lists the meteorological data input options for the ISCLT computer program. All meteorological data may be input by card deck or by a magnetic tape inventory previously generated by ISCLT (see Section 4.1.1.c below). ISCLT accepts STAR summaries with six Pasquill stability categories (A through F) or five Pasquill stability categories (A through E with the E and F categories combined). It does not accept STAR summaries with separate day and night neutral categories. Site-specific mixing heights and ambient air temperature are ISCLT input requirements rather than options. Suggested procedures for developing these inputs are given in Section 2.2.1.2. The remaining meteorological data input options listed in Table 4-1 are identical to the ISCST meteorological data input options discussed in Section 3.1.1.a.

b. Dispersion Model Options. Table 4-2 lists the dispersion model options for the ISCLT computer program. In general, these options correspond to the

TABLE 4-1

METEOROLOGICAL DATA INPUT OPTIONS FOR ISCLT

Input of all meteorological data by card deck or by magnetic tape inventory previously generated by ISCLT

STAR summaries with five or six Pasquill stability categories

Site-specific mixing heights

Site-specific ambient air temperatures

Site-specific wind-profile exponents

Site-specific vertical potential temperature gradients

Rural Mode or Urban Mode 1, 2 or 3

Final or distance dependent plume rise

Wind system measurement height if other than 10 meters

TABLE 4-2

DISPERSION-MODEL OPTIONS FOR ISCLT

Concentration or dry deposition calculations

Inclusion of the effects of gravitational settling and/or deposition in concentration calculations

Inclusion of terrain effects (concentration calculations only)

Cartesian or polar receptor system

Discrete receptors (Cartesian or polar system)

Stack, volume and area sources

Pollutant emission rates held constant or varied by season or by wind speed and stability

Time-dependent exponential decay of pollutants

Inclusion of building wake, stack-tip downwash and buoyancy-induced dispersion effects

Time periods for which concentration or deposition calculations are to be made (seasonal and/or annual)

ISCST dispersion-model options discussed in Section 3.1.1.b. Pollutant emission rates may be held constant or varied by season or by wind speed and stability in ISCLT calculations. The program uses seasonal STAR summaries to calculate seasonal and/or annual concentration or deposition values. Additionally, monthly STAR summaries may be used to calculate monthly concentration or deposition values.

c. Output Options. Table 4-3 lists the ISCLT program output options. A more detailed discussion of the ISCLT output information is given in Section 4.1.3.

The ISCLT program has the capability to generate a master file inventory containing all meteorological and source inputs and the results of all concentration or deposition calculations. This file can then be used as input to future update runs. For example, assume that the user wishes to add a new source and modify an existing source at a previously modeled industrial source complex. Concentration or deposition calculations are made for these or modified sources alone and the results of these calculations in combination with select sources from the original file inventory are used to generate an updated inventory. That is, it is not necessary to repeat the concentration or deposition calculations for the unaffected sources in the industrial source complex in order to obtain an updated estimate of the concentration or deposition values for the combined emissions. The optional master file inventory is discussed in detail in Section 4.2.4.b.

The ISCLT user may elect to print one or more of the following tables:

- The program control parameters, meteorological input data and receptor data
- The source input data
- The seasonal and/or annual average concentration or total deposition values calculated at each receptor for each source or for the combined emissions from select groups or all sources

TABLE 4-3

ISCLT OUTPUT OPTIONS

Master file inventory of meteorological and source inputs and the results of the concentration or deposition calculations

Printout of program control parameters, meteorological data and receptor data

Printout of tables of source input data

Printout of seasonal and/or annual average concentrations or total seasonal and/or annual deposition values calculated at each receptor for each source or for the combined emissions from a select group or all sources

Printout of the contributions of the individual sources to the 10 highest concentration or deposition values calculated for the combined emissions from a select group of all sources or the contributions of the individual sources to the total concentration or deposition values calculated for the combined emissions from a select group of all sources at 10 user-specified receptors

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- The contributions of the individual sources to the 10 receptors with highest concentration (or deposition) values obtained from the combined emissions of select groups of sources; or the contributions of each individual source, as well as the combined sources, to a select group of user specified receptor points; or the maximum 10 concentration (or deposition) values for each source and for the combined sources, determined independently of each other

4.1.2 Data Input Requirements

This section provides a description of all input data parameters required by the ISCLT program. The user should note that some input parameters are not read or are ignored by the program, depending on the values assigned to the control parameters (options) by the user.

a. Program control Parameter Data. These data contain parameters which provide user-control Parameter Data.

Parameter Name	
ISW(1)	Concentration/Deposition Option--Directs the program to calculate either average concentration or total deposition. A value of "1" indicates average concentration is to be calculated and a value of "2" indicates total deposition is to be calculated. If this parameter is not punched, the program defaults to "1" or concentration.
ISW(2)	Receptor Reference Grid System Option--Specifies whether a right-handed rectangular Cartesian coordinate system or a polar system is to be input to the program to form the receptor reference grid system. A value of "1" indicates a Cartesian reference grid system is being input and a value of "2" indicates a polar reference grid system is being input. If this parameter is not punched, the program will default to a value of "1."
ISW(3)	Discrete Receptor Option--Specifies whether a right-handed rectangular Cartesian reference system or polar reference system is used to reference the input discrete receptor points. A value of "1" indicates that the Cartesian reference system is used and a value of "2" indicates that a polar reference system is used. If this parameter is not punched, the program will default to a value of "1."

Parameter Name	
ISW(4)	Receptor Terrain Elevation Option--Specifies whether the user desires to input the terrain elevations for each receptor point or to use the program as a flat terrain model. A value of "0" indicates terrain elevations are not to be input and a value of "1" indicates terrain elevations for each receptor point are to be input. Note that terrain elevations cannot be used with the deposition model. The default for this parameter is no terrain or "0." If equal to "-1," the program assumes input elevations are in meters rather than feet.
ISW(5)	Input/Output File Option--Specifies whether disc file input and/or output is to be used. A value of "0" indicates no file input or output. A value of "1" indicates an output file is to be produced on the output unit specified by ISW(15). A value of "2" indicates an input file is required on the input unit specified by ISW(14). A value of "3" indicates both input and output files are being used. Default for this parameter is "0". It is the user's responsibility to ensure that the correct tapes or files are mounted on the correct units.
ISW(6)	Print Input Data Option--Specifies what input data are to be printed. A value of "0" indicates no input data are to be printed. A value of "1" indicates only the control parameters, receptor points and meteorological data are to be printed. A value of "2" indicates only the source input data are to be printed and a value of "3" indicates all input data are to be printed. The default for this parameter is "0."
ISW(7)	Seasonal/Annual Print Option--Specifies whether seasonal concentration (or deposition) values are to be printed, or annual values only, or both seasonal and annual values. An ISW(7) value of "1" indicates only seasonal output is to be printed, a value of "2" indicates only annual output is to be printed, and a value of "3" indicates both seasonal and annual output are to be printed. If this parameter is not punched or is "0," the program defaults to "3."
ISW(8)	Individual/Combined Sources Print Option--Specifies whether output for individual sources or the combined sources (sum of sources) or both is to be printed. An ISW(8) value of "1" indicates output for individual sources only is to be printed, a value of "2" indicates output for the combined sources only is to be printed, and a value of "3" indicates output for both individual and combined sources is to be printed. The default for this parameter is "3." This parameter is used in conjunction with the parameter NGROUP below. If NGROUP equals "0," all sources input to the program are considered for output under ISW(8). However, if NGROUP is greater than "0," only those sources explicitly or implicitly defined under NGROUP are considered for output under ISW(8). Also, a single source defined under NGROUP is logically treated as combined source output when ISW(8) equals "2" or "3."

Parameter Name	
ISW(9)	Rural/Urban Option--Specifies whether rural or urban modes are to be used (see Table 2-3). A value of "1" specifies Urban Mode 1 and the E and F stability categories are redefined as D. A value of "2" specifies Urban Mode 2 and stability categories A and B are redefined as A, C becomes B, D becomes C, and E and F become D. A value of "3" specifies the Rural Mode and does not redefine the stability categories. The rural Pasquill-Gifford dispersion curves are used with values of 1 through 3. A value of "4" specifies Urban Mode 3, with no stability category adjustment and use of the urban Briggs dispersion curves. If this parameter is not punched or is "0," the program defaults to "3." If file input is used, the program defaults to the value saved on file. The parameter ISW(9) is only used for card input sources and/or tape input sources when ISW(12) equals "1." It should be noted that the use of Urban Modes 1 and 2 are not recommended for regulatory purposes.
ISW(10)	Maximum 10 Print Option--Specifies whether the maximum 10 values of concentration or deposition only are to be printed, or the results of the calculations for all receptors only, or both are to be printed. A value of "1" directs the program to calculate and print only the maximum 10 values and receptors according to ISW(11) or ISW(12) below. Values at receptors other than the maximum 10 are not printed if this option equals "1." A value of "0" directs the program to print the results of the calculations at all receptors; the maximum 10 values are not produced. A value of "2" directs the program to print the results of the calculations at all receptor locations as well as the maximum 10. The default for this parameter is "0." The ISCLT program will print less than 10 values in cases where there are less than 10 concentration (deposition) values greater than zero calculated.
ISW(11)	Maximum 10 Calculation Option 1--This option directs the program to use one of two methods to calculate and print maximum 10 concentration (or deposition) values. If this option is used, option ISW(12) must equal "0." The program determines the maximum values and receptor locations from the set of all receptors input. Method 1: A value of "1" directs the program to calculate and print the maximum 10 values and respective receptors for each individual source and to calculate and print the maximum 10 values and respective receptors for the combined sources independently of each other. The output for individual sources and combined sources will in general show a different set of receptors. Method 2: A value of "2" directs the program to first calculate and print the maximum 10 values and respective receptors for the combined sources (sum of sources) and then print the contribution at each receptor of each individual source to the combined sources maximum 10. This option can only be used if one or more of the following conditions is met:

Parameter
Name

Condition a - The run uses an output tape or data file (user must specify NOFILE, if tape)

Condition b - The run uses an input tape or data file, but has no input data card sources (all are taken from tape; user must specify NOFILE, if tape)

Condition c - The total number of input sources is less than or equal to the minimum of I and J, where

$J = 300$

and

$$I = \frac{(E - (N_x + N_y + 2N_{xy}) - K-L-M)}{(N_{se}(N_xN_y + N_{xy}))} \qquad (4\text{-}1)$$

$E =$ the total amount of program data storage in BLANK COMMON. The design size is 40,000.

$N_x =$ Number of points in the input X-axis of the receptor grid system (NXPNTS)

$N_y =$ Number of points in the input Y-axis of the receptor grid system (NYPNTS)

$N_{xy} =$ Number of discrete (arbitrarily placed) input receptors (NXWYPT)

$N_{se} =$ Number of seasons in the input meteorological data (NSEASN)

$K = N_{se}(N_xN_y+N_{xy})$

$$L = \begin{array}{l} 0 \;;\ \text{if ISW(4) = "0"} \\ \text{OR} \\ N_xN_y+N_{xy};\ \text{if ISW(4) = "1" or "-1"} \end{array}$$

$$M = \begin{cases} 0;\ \text{if ISW(4) = 1 or "-1" and ISW(11) = 2 or} \\ \quad \text{if ISW(7) = 1,or NSEASN = 1,or NGROUP = 0} \\ N_xN_y+N_{xy};\ \text{if ISW(4) = 0 or ISW(11)} \neq \text{2 and if} \\ \quad \text{ISW(7) = 1 and NGROUP = 0 and NSEASN = 1} \end{cases}$$

Parameter Name	
ISW(12)	Maximum 10 Calculation Option 2--This option directs the program to calculate concentration or deposition at a special set of user supplied discrete (arbitrarily placed) receptor points. If this option is used, option ISW(11) must equal "0." A value of "1" directs the program to expect to read from 10 to 50 special receptors at which concentration or deposition is to be calculated. If this option is selected and 10 special receptors are input, both seasonal and annual concentration or deposition values for individual sources and combined sources are printed for the 10 user-specified receptors. If more than 10 special receptors are input, the program assumes the first 10 points are for season 1, the second 10 points are for season 2, and the last 10 points are for annual tables. This option requires the parameter NXWYPT given below to be a multiple of 10. All input tape or data file sources are recalculated with this option. Also, if an input tape is being used, the receptor grid system, discrete receptors and their elevations input from the tape are discarded and the user inputs the new special set of receptor points (with elevations if ISW(4) equals "1" or "-1") via data card.
ISW(13)	Print Output Unit Option--This option is provided to enable the user to print the program output on a unit other than print unit "6." If this value is not punched or a "0" is punched, all print output goes to unit "6." Otherwise, print output goes to the specified unit. Also, if this value is punched non-zero positive, two end-of-file marks are written at the end of the print file. If ISW(13) is a negative value, the end-of-file marks are not written.
ISW(14)	Optional File Input Unit Number--This option is provided to enable the user to assign the unit number from which data are read under ISW(5). If ISW(14) is not punched or is "0," the program defaults to unit "2." If the input data are being read from a mass-storage file, ISW(14) must be set to a negative value. A positive value implies magnetic tape. Note that ISW(14) is the internal file name used by the program to reference the data file and must be equated with the external file name used to assign the file (see Section 4.2.2).
ISW(15)	Optional File Output Unit Number--This option is provided to enable the user to assign the unit number to which tape or output file data are written under ISW(5). If ISW(15) is not punched or is "0", the program defaults to unit "3." If the output data are being written to a mass-storage file, ISW(15) must be set to a negative value. A positive value implies magnetic tape. Note that ISW(15) is the internal file name used by the program to reference the data file and must be equated with the external file name used to assign the file (see Section 4.2.2).

Parameter Name	
ISW(16)	Print Output Paging Option--This option enables the user to minimize the number of print output pages. A value of "1" directs the program to minimize the output pages by not starting a new page with each type of output table. If this option is not punched or is "0". the program will start each unrelated output table on a new page. The user is cautioned not to exercise this option until familiar with the output format because the condensed listing may be confusing.
ISW(17)	Lines Per Page Option--This option is provided to enable the user to specify the number of print lines per page on the output printer. The correct number of lines per page is necessary for the program to maintain the output format. If this value is not punched or is "0", the program defaults to 57 print lines per page.
ISW(18)	Optional Format for Joint Frequency of Occurrence--This parameter is a switch used to inform the program whether it is to use a default format to read the joint frequency of occurrence of speed and direction (FREQ) or to input the format via data card. If this option is not punched or is "0", the program uses the default format given under FMT below. If this option is set to a value of "1", the array FMT below is read by the program.
ISW(19)	Option to Calculate Plume Rise as a Function of Downwind Distance--This option is applicable to all stack sources and if set equal to "0" or not punched, the downwind distance is not considered in calculating the plume rise. If ISW(19) is set equal to "1", the plume rise calculation is a function of downwind distance. ISW(19) is set to "0" if the regulatory default option (ISW(22)) is selected.
ISW(20)	Option to Add the Briggs (1974) Stack-Tip Downwash Correction to Stack Sources--This option is applicable to all stack sources and if set equal to "0" or not punched, no downwash correction is made. If ISW(20) is set equal to "1", the Briggs (1974) downwash correction is applied to the stack height for all stack sources. ISW(20) is set to "1" if the regulatory default option (ISW(22)) is selected.
ISW(21)	Buoyancy-Induced Dispersion Option--Allows the program to modify the dispersion coefficients to account for buoyancy-induced dispersion. A value of "0" directs the program to modify the dispersion coefficients for stack-type sources while a "1" directs the program to bypass the modification. ISW(21) is set to "0" if the regulatory default option (ISW(22)) is selected.
ISW(22)	Regulatory Default Option--If chosen (this option is chosen if ISW (22) = 0, otherwise ISW(22) should be set to 1), the program will internally re-define some user defined input

Parameter
Name

ISW(22) Cont. options to produce a simulation consistent with EPA regulatory recommendations. The following features are incorporated when this option is selected:

1) Final plume rise is used at all downwind receptor locations.
2) Stack-tip downwash effects are included.
3) Buoyancy-induced dispersion effects are parameterized.
4) Default wind profile coefficients are assigned (.07, .07, .10, .15, .35, .55, for the rural mode; and .15, .15, .20, .25, .30, .30 for the urban modes).
5) Default vertical potential temperature gradients are assigned (A:0.0, B:0.0, C:0.0, D:0.0, E:0.02, F:0.035 °K/m)
6) A decay half-life of 4 hours is assigned if SO_2 is modeled in an urban mode; otherwise, no decay is assigned.

Note that the model selects the appropriate urban or rural mixing height, and that building downwash is calculated when appropriate.

ISW(23) Pollutant Indicator Switch--If SO_2 is modelled the user should set this option equal to "0". If a pollutant other than SO_2 is modelled the user should set this option equal to "1". Note, this switch is only used when ISW(22) = 0.

ISW(24) Input Debug Switch -- If the user wants input data printed as soon as it is entered set this option to "0", otherwise set this option to "1". Note: any input data resulting from the selection of ISW(6) will also be printed.

NSOURC Number of Data Card Input Sources--This parameter specifies the number of input card image sources. This includes card images that specify a new source being entered and card images that specify modifications or deletions to sources input from tape or data file. If this value is not punched or is "0", the program assumes all sources are input from tape or data file. Also, if a negative value is punched for this parameter, the program will continue to read source data card images until it encounters an end-of-file or a negative source identification number in the parameter NUMS below. There is no limit to the number of sources the program can process when using tape output (see ISW(11)).

NGROUP Number of Source Combination Groups--This parameter is used to select concentration (deposition) calculations for specific sources or source combinations to be printed under the parameter ISW(8) above. A source combination consists of one or more sources and is the sum of the concentrations (deposition) calculated for those sources. If the user desires only individual source output or only all sources combined or both, the parameter NGROUP is not punched or is set equal to "0" and ISW(8) is set according to which option

Parameter
Name

NGROUP
Cont.

the user desires. Also, if NGROUP is not punched or is set equal to "0", the parameters NOCOMB and IDSOR below are omitted from the input data. However, if NGROUP is set greater than zero, the program assumes the user desires to NGROUP restrict the output of concentration tables to select individual sources or select combinations of sources or both, depending on ISW(8). The maximum value for NGROUP is 20. If more than 20 source combinations are desired they must be produced in multiple runs of ISCLT. This can be done by specifying an output tape or data file on the first execution. The user would then use this tape for input on subsequent runs to produce the remaining desired source combinations. Also, only a few of the data cards and values from the initial data deck are required on subsequent runs. The parameter NGROUP cannot be used or punched non-zero unless one or more of the following conditions is met:

Condition a - The run uses an output tape or data file (user must specify NOFILE, if tape)

Condition b - The run uses an input tape or data file, but has no input data card sources (all are taken from tape, NSOURC = "0") (user must specify NOFILE, if tape)

Condition c - The total number of input sources (NSOURC + input tape sources) is less than or equal to the minimum of I and J, where

$$J = 300$$

and

$$I = [E - (N_x + N_y + 2N_x\ N_y) - K - L - M]/[N_{se}(N_x\ N_y + N_{xy})] \qquad (4\text{-}2)$$

All of the variables in this equation except K are the same as those defined under ISW(11) above.

$$K = \begin{cases} 0 & ;\ \text{if } ISW(8)=1 \text{ and } ISW(11)\neq 2 \\ \text{or} & \\ N_{se}(N_xN_y+N_{xy}); & \text{if } ISW(8)\neq 1 \text{ or } ISW(11)=2 \end{cases}$$

Parameter
Name

NXPNTS X-Axis/Range Receptor Grid Size-This parameter specifies the number of east-west receptor grid locations for the Cartesian coordinate system X-axis, or the number of receptor grid ranges (rings) in the polar coordinate system, depending on which receptor grid system is chosen by the user under parameter ISW(2). This is the number of X-axis points to be input or the number of X-axis points to be automatically generated by the program. A value of "0" (not punched directs the program to assume there is no regular receptor grid being used. The maximum value of this parameter is related to other parameter values and is given by the equation

$$E \geq [N_x+N_y+2N_{xy}] + [(KN_s+I)(N_xN_y+N_{xy})] \qquad (4\text{-}3)$$

where all variables in the above equation are the same as those defined under ISW(11) above except K and I, which are defined as

$$K = \begin{array}{ll} 1 \ ; & \text{if ISW(8)=1 and ISW(11)} \neq 2 \\ \text{or} & \\ 2 \ ; & \text{if ISW(8)} \neq 1 \text{ or ISW(11)=2} \end{array}$$

$$I = \begin{array}{ll} 0 \ ; & \text{if ISW(4)=0 (no terrain)} \\ \text{or} & \\ 1 \ ; & \text{if ISW(4)=1 or "-1"} \end{array}$$

This parameter is ignored by the program if tape or data file input is being used.

NYPNTS Y-Axis/Azimuth Receptor Grid Size--This parameter specifies the number of north-south receptor grid locations for the Cartesian coordinate system Y-axis, or the number of receptor azimuth bearings from the origin in the polar coordinate system, depending on which receptor grid system is chosen by the user under parameter ISW(2). If the parameter NXPNTS is set non-zero, the parameter NYPNTS must also be non-zero. The maximum value of this parameter is given by the equation under NXPNTS above. The parameter NYPNTS is ignored by the program if tape or data file input is being used.

NXWYPT Number of Discrete (Arbitrarily Placed) Receptors--This parameter specifies the total number of discrete receptor points to be input to the program. A value of "0" (not punched) directs the program to assume no discrete receptors are being used. This parameter must be set to a multiple of 10 if option ISW(12) is selected. Also, the maximum value of this parameter is limited by the equation given under NXPNTS above. This parameter is ignored by the program if input tape or data file is being used, except in the case where the ISW(12) option has been selected.

Parameter Name	
NSEASN	Number of Seasons--This parameter specifies the number of seasons or months in the input meteorological data. A value of "0" (not punched) defaults to "1". Also, if annual meteorological data are being used, a value of "1" should be specified. The maximum value of this parameter is "4". If monthly STAR summaries and seasonal average mixing heights and ambient air temperatures are used to calculate monthly concentration or deposition values for each month of the year, four separate program runs, each containing three "seasons" (months), are required. This parameter is ignored by the program if an input tape or data file is being used.
NSTBLE	Number of Paquill Stability Categories--This parameter specifies the number of Pasquill stability categories in the input joint frequency of occurrence of wind speed and direction (FREQ). A value of "0" (not punched) causes the program to default to "6" (maximum). This parameter is ignored by the program if an input tape or data file is being used.
NSPEED	Number of Wind Speed Categories--This parameter specifies the number of wind speed categories in the input joint frequency of occurrence of wind speed and direction (FREQ). A value of "0" (not punched) causes the program to default to "6" (maximum). This parameter is ignored by the program if an input tape or data file is being used.
NSCTOR	Number of Wind Direction Sector Categories--This parameter specifies the number of wind direction sector categories in the input joint frequency of occurrence of wind speed and direction (FREQ). A value of "0" (not punched) causes the program to assume the standard "16" (maximum) sectors are to be used (see Section 2.2.1.2). This parameter is ignored by the program if an input tape or data file is being used.
NOFILE	Tape Data Set File Number--This parameter specifies the output tape file number or, if only an input tape is being used, the input tape file number. This parameter is used by the ISCLT program to position the tape at the correct file if multiple passes through the data are required. This parameter must be input if the user is using Condition a or Condition b under ISW(11) and/or under NGROUP. This parameter does not apply to runs that use mass-storage (assumed one file) or runs that satisfy Condition c under ISW(11) and/or NGROUP. Also, the user must position input and output tapes at the correct files prior to executing the ISCLT program.

Parameter Name	
NOCOMB	Number of Sources Defining Combined Source Groups--This parameter is not read by the program if the parameter NGROUP above is zero or not punched. Otherwise, this parameter is an array of NGROUP values where each value gives the number of source identification numbers used to define a source combination. The source identification number is that number assigned to each source by the user under the source input parameter NUMS below. An example and a more detailed discussion of the use of this parameter is given under IDSORC below. A maximum of 20 values is provided for this array.
IDSORC	Combined Source Group Defining Sources--This parameter is not read by the program if the parameter NGROUP above is zero or not punched. Otherwise, this parameter is an array of source identification numbers that define each combined source group to be output. The values punched into the array NOCOMB above indicate how many source identification numbers are punched into this array successively for each combined source output. The source identification numbers can be punched in two ways. The first is to punch a positive value directing the program to include that specific source in the combined output. The second is to punch a negative value. When a negative value is punched, the program includes all sources with identification numbers less than or equal to it in absolute value. Also, if the negative value is preceded by a positive value in the same defining group, that source is also included with those defined by the negative number, but no sources with a lesser source identification number are included. For example, assume NGROUP above is set equal to 4 and the array NOCOMB contains the values 3, 2, 1, 0. Also, assume the entire set of input sources is defined by the source identification numbers 5, 72, 123, 223, 901, 902, 1201, 1202, 1205, 1206, and 1207. To this point we have a total of 11 input sources and we desire to see 4 combinations of sources taken from these 11. Also, the array NOCOMB indicates that the first 3 values in the array IDSORC defines the first source combination, the next 2 values (4th and 5th) in IDSORC define the second combination, the 6th value in IDSORC defines the third combination and the last combination has no defining (0) sources so the program assumes all 11 sources are used. Similarly, let the array IDSORC be set equal to the values 5, 72, -223, 1201, -1207, -902. The program will first produce combined source output for source 5, and all sources from 72 through 223. The second combined source output will include sources 1201 through 1207. The third will include source numbers 1 through 902 and the last will include all sources input. Note that the source identification numbers in each defining group are in ascending order of absolute value. Also, if ISW(8) equals "2" (combined output only) and there are groups with only one positive source number (individual sources), the program logically treats these individual sources as combined sources.

Parameter Name	
FMT	Optional Format for Joint Frequency of Occurrence--This parameter is an array which is read by the program only if ISW(18) is set to a value of "1". The array FMT is used to specify the format of the joint frequency of occurrences of wind speed and direction data (FREQ, STAR summary, $f_{i,j,k,l}$ in Table 2-4). The format punched, if used, must include leading and ending parentheses. If ISW(18) is not punched or is set to a value of "0", the parameter FMT is omitted from the input deck and the program uses the default format "(6F10.0)". This default format specifies that there are 6 real values per card occupying 10 columns each, including the decimal point (period), and the first value is punched in columns one through ten. If the user has received the STAR data from an outside source, the deck must also be checked for the proper order as well as format.

b. Receptor Data These data consist of the (X,Y) or (range, azimuth) locations of all receptor points as well as the elevations of the receptors above mean sea level. The minimum distance in meters between source and receptor for which calculations are made is given by:

Stack Sources:

$$\text{minimum distance} = \begin{cases} 1 & \text{; no wake effects} \\ \text{or} & \\ \text{MAX(1,3*HB)} & \text{; wake effects, squat building} \\ \text{or} & \\ \text{MAX(1,3*HW)} & \text{; wake effects, tall building} \end{cases}$$

Volume Sources:

$$\text{minimum distance} = 1 + 2.15\text{*SIGYO}$$

Area Sources:

$$\text{minimum distance} = 1 + 0.5\text{*BW}$$

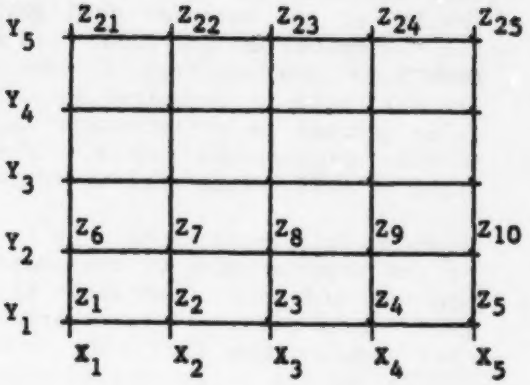
Where:

HB = height of building
HW = width of building
SIGYO = standard deviation of the lateral source dimension of building
BW = width of area source

Parameter Name	
X	Receptor Grid System X-Axis or Range--This parameter is read by the program only if the parameters NXPNTS and NYPNTS are non-zero and only if an input tape or data file is not being used. This parameter is an array of values in ascending order that defines the X-axis or ranges (rings) (depending on ISW(2)) of the receptor grid system in meters. If only the first 2 values on the input card are punched and the parameter NXPNTS is greater than 2, the program assumes the X-axis (range) is to be generated automatically and assumes the first value punched is an increment used to generate the remaining NXPNTS evenly-spaced points. If all receptor points are being input, NXPNTS values must be punched.
Y	Receptor Grid System Y-Axis or Azimuth--This parameter is read by the program only if the parameters NXPNTS and NYPNTS are non-zero and only if an input tape or data file is not being used. This parameter is an array of values in ascending order that defines the Y-axis or azimuth bearings (depending on ISW(2)) of the receptor grid system in meters or degrees. If only the first 2 values on the input card are punched (third and fourth values are zero) and the parameter NYPNTS is greater than 2, the program assumes the first value punched is the increment used to generate the remaining NYPNTS evenly-spaced (rectangular or angular) points. If all receptor points are being input, NYPNTS values must be punched. If polar coordinates are being used, Y is measured clockwise from zero degrees (north).
Z	Elevation of Grid System Receptors--This parameter is not read by the program if the parameter ISW(4) is zero or if an input tape is being used or if NXPNTS or NYPNTS equals zero. This parameter is an array specifying the terrain elevation (feet if ISW(4)=1, meters if ISW(4)=-1) above mean sea level at each receptor of the Cartesian or polar grid system. There are NXPNTS • NYPNTS values read into this array. The program starts the input of values with the first Y coordinate specified and reads the elevations for each X coordinate at that Y in the same order as the X coordinates were input. A new data card is started for each Y value and the NXPNTS elevations for that Y are read. The program will expect NYPNTS groups of data cards with NXPNTS elevation values punched in each group. For example, assume we have a 5 by 5 Cartesian or polar receptor array. The values Z_1 through Z_5 are read from the first card group, the values Z_6 through Z_{10} from the second card group and Z_{21} through Z_{25} from the last card group.

Parameter Name

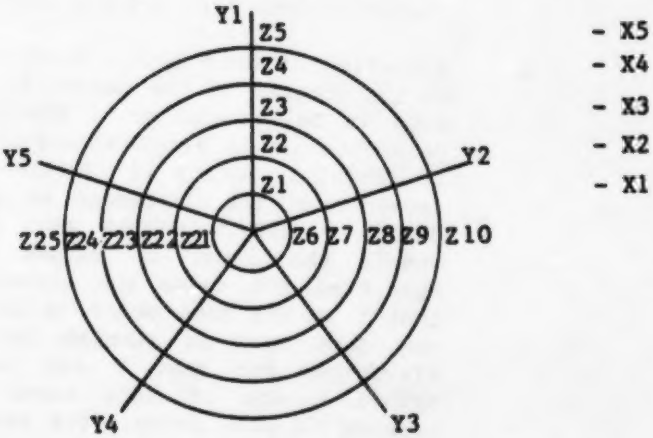
Rectangular



Y_5
Y_4
Y_3
Y_2
Y_1
Z_{21}
Z_{22}
Z_{23}
Z_{24}
Z_{25}
Z_6
Z_7
Z_8
Z_9
Z_{10}
Z_1
Z_2
Z_3
Z_4
Z_5
X_1
X_2
X_3
X_4
X_5

Z
(Cont.)

Polar



Y1
Z5
Z4
Z3
Z2
Z1
Y5
Y2
Z25
Z24
Z23
Z22
Z21
Z6
Z7
Z8
Z9
Z10
Y4
Y3
- X5
- X4
- X3
- X2
- X1

Parameter Name	
X (Discrete)	Discrete (Arbitrarily Placed) Receptor X or Range--This parameter is not read by the program if the parameter NXWYPT is zero or if the program is using an input tape or data file with the ISW(12) option set to zero. This parameter is an array defining all of the discrete receptor X points. The values are either east-west distances or radial distances in meters, depending on the type of reference system specified by ISW(3). NXWYPT points are read by the program.
Y (Discrete)	Discrete (Arbitrarily Placed) Receptor Y or Azimuth--This parameter is not read by the program if the parameter NXWYPT is zero or if the program is using an input tape or data file with the ISW(12) option set to zero. This parameter is an array defining all of the discrete receptor Y points in meters and degrees. The values are either north-south distances or azimuth bearings (angular distances) measured clockwise from zero degrees (north depending on the type of reference system specified by ISW(3). NXWYPT points are read by the program.
Z (Discrete)	Elevation of the Discrete (Arbitrarily Placed) Receptors--This parameter is not read by the program if the parameter ISW(4) is zero or if the parameter NXWYPT equals zero of if an input file is being used with the ISW(12) option equal to zero. This parameter is an array specifying the terrain elevation (feet if ISW(4)=1, meters if ISW(4)=-1) at each of the NXWYPT discrete receptors:

c. Identification Labels and Model Constants. These data consist of parameters pertaining to heading and identification labels and program constants. These data, except for TITLE, are not read by the program if an input tape or data file is being used.

Parameter Name	
TITLE	Page Heading Label--This parameter is an array that allows up to 80 characters of title information to be printed as the first line of each output page.
UNITS	Concentration/Deposition and Source Units Label--This parameter is an array used for the optional input of two unit labels. The first 40 characters of this array are provided for an optional output units label for concentration or deposition. This label is defaulted to "micrograms per cubic meter" for concentration and "grams per square meter" for deposition, if the parameter TK below is not punched or is "0". The second 40 characters of this array are provided for

Parameter Name	
UNITS Cont.	an optional source input units label. This label is defaulted to "grams per second" for concentration or "grams" for deposition for stacks and volume sources and to "grams per second per square meter" or "grams per square meter" for area sources, if the parameter TK below is not punched or is "0".
ROTATE	Wind Direction Correction Angle--This parameter is used to correct for any difference between north as defined by the X, Y reference grid system and north as defined by the weather station at which the wind direction data were recorded. The value of ROTATE (degrees) is subtracted from each wind-direction sector angle (THETA). This parameter is positive if the positive Y axis of the reference grid system points to the right of north as defined by the weather station. Most weather stations record direction relative to true north and the center of most grid systems are relative to true north. However, some weather stations record direction relative to magnetic north and the ends of some UTM (Universal Transverse Mercator) zones are not oriented towards true north. The user is cautioned to check the wind data as errors in the wind direction distribution will lead to erroneous program results. The default value of ROTATE is "0".
TK	Model Units Conversion Factor--This parameter is provided to give the user flexibility in the source input units used and the concentration or deposition output units desired. This parameter is a direct multiplier of the concentration or deposition equation. If this parameter is not punched or is set to a value of "0", the program defaults to "1×10^{6}" micrograms per gram for concentration and to "1" for deposition. This default assumes the user desires concentration in micrograms per cubic meter or deposition in grams per square meter and the input source units are grams per second or total grams for stack and volume sources and grams per second per square meter or grams per square meter for area sources, depending on whether the program is to calculate concentration or deposition. Also, if the default value for this parameter is selected, the program defaults the unit labels in the array UNITS above. If the user chooses to input this parameter for other units, he must also input the units labels in UNITS above. This parameter corresponds to K in Equations (2-51), (2-56), (2-57), and (2-58).
ZR	Weather Station Recording Height--This parameter is the height above ground level in meters at which the meteorological data were recorded. If this parameter is not punched or has a value of "0", the program defaults to "10" meters. This parameter corresponds to Z_1 in Equation (2-1).
G	Acceleration Due to Gravity--This parameter, which is used in the plume rise calculations, is the acceleration due to gravity. If this parameter is not punched or has a value of

Parameter Name	
G Cont.	"0", the program uses "9.8" meters per second squared as the default value. This parameter corresponds to g in equation (2-3).
DECAY	Decay Coefficient--This parameter is the coefficient (seconds^{-1}) of time-dependent pollutant removal by physical or chemical processes (Equations (2-20), (2-21)). If SO_2 is modeled in an Urban Mode and the regulatory default option (ISW(22)) is chosen, the program assigns a decay coefficient corresponding to a half life of four hours. Otherwise, pollutant decay is not considered.

d. Meteorological Data. These data are the meteorological input parameters classified according to one or more of the categories of wind speed, Pasquill stability, wind direction and season or annual. These parameters are not read by the program if an input tape or data file is being used.

FREQ	Joint Frequency of Occurrence--This parameter array consists of the seasonal or annual joint frequency of occurrence of wind-speed and wind-direction categories classified according to the Pasquill stability categories (STAR summary, $f_{i,j,k,\ell}$ in Table 2-4). This parameter has no default and must be input in the correct order. The program begins by reading the joint frequency table for season 1 (winter) and stability category 1 (Pasquill A stability). The first data card contains the joint frequencies of wind speed categories 1 through 6 (1 through NSPEED) for the first wind direction category (north). The second data card contains the joint frequencies of wind speed categories 1 through 6 for the second wind direction category (north-northeast). The program continues in this manner until the joint frequencies of the last direction category (north-northwest) for stability category 1, season 1 have been read. The program then repeats this same read sequence for stability category 2 (Pasquill B stability) and season 1. When all of the stability category values for season 1 have been read, the program repeats the read sequence for season 2, season 3, etc., until all of the joint frequency values have been read. There are a total of NSPEED•NSCTOR•NSTBLE•NSEASN data cards. If the total sum of the joint frequency of occurrences for any season (or annual) does not add up to 1, the program will automatically normalize the joint frequency distribution by dividing each joint frequency by the total sum. Also, the program assumes stability categories 1 through 6 are Pasquill stabilities A FREQthrough F. Seasons 1 through 4 are normally winter, spring, summer and fall. See the parameter FMT above for the format of these data.

Parameter Name	
TA	Average Ambient Air Temperature--This parameter array consists of the average ambient air temperatures ($T_{a;k,\ell}$ in Table 2-4), classified according to season (or annual) and stability category, in degrees Kelvin. One data card is read for each season (1 to NSEASN) with the temperature values for stability categories 1 through NSTBLE punched across the card. When the program has completed reading these data cards, it will scan all of the values in the order of input and, if any value is not punched or is zero, the program will default to the last non-zero value of TA it encountered.
HM	Mixing Heights--This parameter array consists of the median mixing layer height in meters ($H_{m,i,k,\ell}$ in Table 2-4) classified according to wind speed, stability and season (or annual). The program begins reading the mixing layer heights for season 1. The program reads the mixing layer height values for each wind speed category (1 to NSPEED) from each card. There are NSTBLE (1 through NSTBLE) cards read for each season. The program scans each value input in the order of input and, for each season, if a zero or non-punched value is found, the program defaults to the last non-zero value encountered within the values for that season. The ISCLT program automatically uses a mixing height value of 10000 meters for the E and F stability categories when the program is run in the Rural Mode.
DPDZ	Potential Temperature Gradient--This parameter array consists of the vertical gradients of potential temperature ($\partial\theta/\partial z_{i,k}$ in Table 2-4) classified according to wind speed and stability category in units of degrees Kelvin per meter. There are NSTBLE (1 through NSTBLE) data cards read with the values for wind speed categories 1 through NSPEED read from each card. A value of $\partial\theta/\partial z$ greater than zero indicates stable thermal stratification and a value of $\partial\theta/\partial z$ less than zero indicates unstable thermal stratification. However, because a blank input field is interpreted as zero, the program assumes a zero input value means a default value is desired. Also, because the same plume rise equation is used for adiabatic and unstable conditions, a negative input value will direct the program to use the plume rise equations for adiabatic or unstable thermal stratification. If the first value on a data card is not punched or is zero, a default value is used that depends on the stability category. If the stability category is A, B, C or D, the value is left as a zero and the adiabatic/unstable plume rise equation is used. However, if the stability category is E or F, the value defaulted is 0.02 degrees Kelvin per meter for E and 0.035 degrees Kelvin per meter for F stability. When any of the second through sixth values of DPDZ on a data card are input as a zero or are blank, the program will default to the previous value on the data card. If the regulatory default option is selected (ISW(22)=0) the default values will override any user input values.

Parameter Name	
UBAR	Wind Speed--This parameter array consists of the median wind speeds in meters per second (u_i in Table 2-4) for the wind speed categories used in the calculation of the joint frequency of occurrence of wind speed and direction (STAR summary). There are NSPEED values read from this card. If any value is not punched or is zero, the program defaults to the following set of values: 1.5, 2.5, 4.3, 6.8, 9.5 and 12.5 meters per second.
THETA	Wind Direction--This parameter array consists of the median wind direction angles in degrees for the wind-direction categories used in the calculation of the joint frequency of occurrence of wind speed and direction (STAR summary). There are NSCTOR values read from 1 to 2 data cards and if the first two values of this array are not punched or are zero, the program defaults to the following standard set of values: 0, 22.5, 45, 67.5, 90, ... , 337.5 degrees (N, NNE, NE, ..., NNW). The wind direction is that angle from which the wind is blowing, measured clockwise from zero degrees (north).
P	Wind Speed Power Law Exponent--This parameter array consists of the wind speed power law exponent (p in Equation (2-1)) classified according to wind speed and stability categories 1 through NSTBLE. If the first value on any data card in this set is not punched or is zero, the program defaults to the value from the following set of values: Rural A = .07, B = .07, C = .10, D = .15, E = .35, F = .55; Urban A = .15, B = .15, C = .20, D = .25, E = .30, F = .30 depending on the stability category A through F. Also, if any of the second through last values on a card is not punched or is zero, the value is defaulted to the previous value on the data card. If a negative value is input, the result is a wind speed power law exponent of zero. If the regulatory default option is selected (ISW(22)=0) the default values will override any user-input values.

e. Source Data. These data consists of all necessary information required for each source. These data are divided into three groups: (1) parameters that are required for all source types, (2) parameters that are required for stack type sources, and (3) parameters that are required for volume sources and area sources. The order of input of these parameters is given at the end of this section.

Parameter Name	
NUMS	Source Identification Number--This parameter is the source identification number and is a 1- to 5-digit integer. If this number is negative, the program assumes NUMS is only a flag to terminate the card source input data. Also, if NUMS is not punched or is zero, the program will default NUMS to the relative sequence number of the source input. This number cannot be defaulted if source data are also being input from tape or data file. Sources must be input in ascending order of the source identification number.
DISP	Source Disposition--This parameter is a flag that tells the program what to do with the source. If this parameter is not punched or has a value of "0", the program assumes this is a new source for which concentration or deposition is to be calculated. Also, if the program is using an input tape or data file, this new source will be merged into the old sources from file or will replace a file source with the same source identification number. If the parameter DISP has a value of "1", the program assumes that the file input source having the same source identification number is to be deleted from the source inventory. The program removes the source as well as the concentration or deposition arrays for the source. If the parameter DISP has a value of "2", the program assumes the source strengths to be read from data card for this source are to be used to rescale the concentration or deposition values of the tape input source with the same source identification number. The new source strengths input from card replace the old values taken from the input tape and the concentration or deposition arrays taken from tape are multiplied by the ratio of the new and old source strengths. The DISP option equal to "2" can only be used if QFLG equals zero and the tape input source has QFLG equal to zero.
TYPE	Source TYPE--This parameter is a flag that tells the program what type of source is being input. If this parameter is not punched or is "0", the program assumes a stack source. If this parameter has a value of "1", the program assumes a volume source. Similarly, if this parameter has a value of "2", an area source is assumed.
QFLG	Source Emission Option--This parameter is a flag that tells the program how the input source emissions are varied. If this value is not punched or is "0", the program assumes the source emissions vary by season (or annual) and only NSEASN values are read by the program. If this parameter has a value of "1", the program assumes the source emissions vary by stability category and season. If this parameter has a value of "2", the program assumes the source emissions vary by wind speed category and season. If this parameter has a value of "3", the program assumes the source emissions vary by wind speed category, stability category and season. The order of input of the source strengths under each of these options is discussed under the parameter Q below.

Parameter Name	
DX	Source X Coordinate--This parameter gives the Cartesian X (east-west) coordinate in meters of the source center for stack and volume sources and the southwest corner for area sources (X in Table 2-6) relative to the origin of the reference grid system being used.
DY	Source Y Coordinate--This parameter gives the Cartesian Y (north-south) coordinate in meters of the source center for stack and volume sources and the southwest corner for area sources (Y in Table 2-6) relative to the origin of the reference grid system being used.
H	Height of Emission--This parameter gives the height above ground in meters of the pollutant emission. For volume sources, this is the height to the center of the source.
ZS	Source Elevation--This parameter gives the terrain elevation in meters above mean sea level at the source location and is not used by the program unless receptor terrain elevations are being used.
Q	Source Emission--This parameter array gives the emission rate of the source for each category specified by QFLG above. If QFLG above is "0", NSEASN values are read from one data card. IF QFLG is "1", NSEASN data cards are read with the source emission values for stability categories 1 through NSTBLE read from each card. If QFLG is "2", NSEASN data cards are read with the source emission values for wind speed categories 1 through NSPEED read from each card. If QFLG is "3", NSPEED (1 through NSPEED) source emission values are read from each data card and there are NSTBLE (1 through NSTBLE) data cards read for each season. There are no default values provided for the parameter Q and the program assumes "0" is a valid source emission. the input units of source emission are:

PARAMETER Q

Source Type	Concentration	Deposition
Stack or Volume	mass per unit time (g/sec)*	total mass (g)*
Area	mass per unit time per unit area ($g/sec \bullet m^2$))*	total mass per unit area (g/m^2)*

*Default units

Parameter Name	
NVS	Number of Particulate Size Categories--This parameter gives the number of particulate size categories in the particulate distribution used in calculating ground-level deposition or concentration with deposition occurring. If ground-level deposition (ISW(1) = "2") is being calculated, this parameter must be punched and has a maximum value of 20. Also, if the program is calculating concentration and this value is punched greater than zero, concentration with deposition occurring is calculated. If the parameter NVS is greater than zero, the program reads NVS values for each of the parameter variables VS, FRQ and GAMMA below.
VS	Settling Velocity--This parameter array is read only if NVS above is greater than zero. This parameter is the settling velocity in meters per second for each particulate size category (1 through NVS). No default values are provided for this parameter.
FRQ	Mass Fraction of Particles--This parameter is read only if NVS above is greater than zero. This parameter is the mass fraction of particulates contained in each particulate size category (1 through NVS). No default values are provided for this parameter.
GAMMA	Surface Reflection Coefficient--This parameter array is read only if NVS above is greater than zero. This parameter is the surface reflection coefficient for each particulate size category (1 through NVS). A value of "0" indicates no surface reflection (total retention). A value of "1" indicates complete reflection from the surface. The reflection coefficient range is from 0 to 1 and no default values are provided.
Stack Source Parameters	
TS	Stack Gas Exit Temperature--This parameter gives the stack gas exit temperature (T_s in Table 2-6) in degrees Kelvin. If this parameter is zero, the exit temperature is set equal to the ambient air temperature. If this parameter is negative, its absolute value is added to the ambient air temperature to form the stack gas exit temperature. For example, if the stack gas exit temperature is 15 degrees Celsius above the ambient temperature, enter TS as -15 (the minus sign is used by the program only as a flag).
VEL	Stack Gas Exit Velocity--This parameter gives the stack gas exit velocity in meters per second.
D	Stack Diameter--This parameter gives the inner stack diameter in meters and no default is provided.

Stack Source Parameters

HB	Building Height--This parameter gives the height above ground level in meters of the building adjacent to the stack. This parameter and BW below control the wake effects option. If HB and BW are punched non-zero, wake effects for the respective source are considered. However, if HB and BW are not punched or both equal "0", wake effects for the respective source are not considered (see Section 2.4.1.1.d).
BW	Building Width--This parameter gives the width in meters of the building adjacent to the stack. If the building is not square, input the dimension of a square building of equal horizontal area. If HB is not punched or is zero, this value should not be punched.
WAKE	Supersquat Building Wake Effects Equation Option--This option is used to control the equations used in the calculation of the lateral virtual distance (Equations (2-37) and (2-38)) when the effective building width to height ratio (BW/HB) is greater than 5. If this parameter is not punched or has a value of "0" and the width to height ratio is greater than 5, the program will use Equation (2-37) to calculate the lateral virtual distance producing the upper bound of the concentration or deposition for the source. If this parameter has a value of "1", the program uses Equation (2-38) producing the lower bound of the concentration or deposition for the source. The appropriate value for this parameter depends on building shape and stack placement with respect to the building (see Section 2.4.1.1.d).

Volume Source Parameters

SIGYO	Standard Deviation of the Crosswind Distribution--This parameter gives the standard deviation of the crosswind distribution of the volume source (σ_{yo} in Table 2-6) in meters. See Section 2.4.2.3 to determine the correct value for this parameter. No default value is provided.
SIGZO	Standard Deviation of the Vertical Distribution--This parameter gives the standard deviation of the vertical distribution of the volume source (σ_{zo} in Table 2-6) in meters. See Section 2.4.2.3 to determine the correct value for this parameter. No default value is provided for this parameter.

Area Source Parameters

XO	Width of Area Source--This parameter gives the width of the area source (x_o in Table 2-6) in meters. This parameter

XO Cont.	should be the length of one side of the approximately square area source. No default is provided for this parameter.

f. Source Data Input Order. There are from one to four data input card groups of one or more cards each required to input the source data. The data cards and parameters required depend on the source type (TYPE) and on the parameters DISP, QFLG, NVS and the concentration/deposition option parameter ISW(1). Card Group 17 is always included in the input deck for each source input (1 to NSOURC). Card group 17a through 17c are included only if NVS on Card Group 17 is non-zero. Card Group 17d is included only if DISP on Card Group 17 equals "0" or "2". The order of input of these source cards is Card Group 17 followed by those used from 17a through 17d for each successive source input. DO NOT stack all of 17 together, all of 17a together, etc. or the program will terminate in error.

Source Input
Card Group 17

Required Source Parameters for Card Group 17--The parameters read from the first data card for each source and their order are:

Stack Sources -- NUMS, DISP, TYPE, QFLG, DX, DY, H, ZS, TS, VEL, D, HB, BW, WAKE, NVS
Volume Sources - NUMS, DISP, TYPE, QFLG, DX, DY, H, ZS, SIGYO, SIGZO, NVS
Area Sources --- NUMS, DISP, TYPE, QFLG, DX, DY, H, ZS, XO, NVS

If the parameter DISP on this card is set to value of "0", all parameters on this card are expected to have the correct value and the program may read Card Groups 17a, 17b and 17c (depending on NVS) and will read Card Group 17d. If DISP is set to a value of "1", only the parameters NUMS and DISP are referenced (required) on this card, the program assumes it is to delete an incoming tape or data file source and only this data card is read for this source. If DISP is set up to a value of "2", only the parameters NUMS, DISP and QFLG are referenced (required) on this card because the program assumes it is to read the source strengths from Card Group 17d and to rescale the concentration or deposition of an incoming tape or data file source. Parameters not referenced on this first data card are set from tape or date file source data by the program.

Source Input
Card Groups
17a, 17b,
and 17c

Source Particulate Distribution Data--This card group consists of three sets of one or more data cards each and is read by the program only if DISP is set to "0" and the parameter NVS is set to a value greater than zero for concentration calculations with deposition occurring or for deposition calculations. The first data card(s) contains the values of the parameter array VS, the second contains the values of the parameter array FRQ and the third contains the values of the parameter array GAMMA. A total of NVS values are read from each set of cards.

Source Input
Card Group 17d

Source Emissions--the last input card group for a source contains the source emission values for the source. This card group consists of one or more data cards and is read only if the parameter DISP is not equal to "1". The number of cards required and the order of values input depends on the parameters QFLG and is given under the source strength parameter Q above.

4.1.3. Output Information

The ISCLT program generates five categories of program output. Each category is optional to the user. That is, the user controls what output other than warning and error messages the program generates for a given run. In the following paragraphs, each category of output is related to the specific input parameter that controls the output category. All program output are printed except for magnetic tape or data file output.

a. Input Parameters Output. The ISCLT program will print all of the input data except for source data if the parameter ISW(6) is set equal to a value of "1" or '3". An example of this output is shown in Appendix D.

b. Source Parameters Output. The ISCLT program will print the input card and tape source data if the parameter ISW(6) is set to a value of "2" or "3". An example of the printed source data is shown in Appendix D.

c. Seasonal/Annual Concentration or Deposition. The parameter ISW(1) specifies whether the program is to calculate concentration or deposition and the parameter NSEASN specifies if seasonal or annual input meteorological data is being used. The option ISW(7) is used to specify whether seasonal output or annual output or both is to be generated. If the input meteorological data are seasonal (winter, spring, summer, fall), the program can be directed to produce tables of seasonal as well as annual concentration or deposition by setting the parameter ISW(7) equal to "0" or "3". Also, only seasonal tables are produced if ISW(7) equals "1". If the parameter NSEASN is set equal to a value of "1" and only annual output is selected (ISW(7)="2"), the program labels the output concentration or deposition as annual calculations. However, if seasonal output is selected with NSEASN equal to "1", the output tables are labeled seasonal. Also, all seasonal output is labeled season 1, season 2, etc., requiring the user to keep track of the actual meteorological season. Example Annual output tables are shown in Appendix D.

d. Concentration or Deposition Printed for the Maximum 10 and/or All Receptor Points. The ISCLT program is capable of printing the concentration or deposition calculations for each receptor point input to the program or printing only the maximum 10 of those receptors or both. The parameter ISW(10) is used to determine which calculations are to be printed. Examples of output tables giving the calculations at all points and the maximum 10 are given in Appendix D.

e. Magnetic Tape or Data File Output. The ISCLT program will write all input data and all concentration (deposition) calculations to magnetic tape or data file. These data are written to the logical unit number specified by the parameter ISW(15). This tape or data file must be assigned to the run prior to the execution of the ISCLT program, positioned to the correct file and must be equated to the logical unit number given in ISW(15). ISW(15) must be a positive value for magnetic tape or a negative value for mass storage. If seasonal meteorological input data are used, the program saves only seasonal concentration (deposition) on the output file and if input is annual, only annual calculations are saved. This output file can be read back into the ISCLT program to print tables not output in the original run and/or to modify the source inventory for corrections or updates in the source emissions.

4.2 User's Instructions for the ISCLT Program

4.2.1 Program Description

The ISC long-term (ISCLT) program is designed to calculate ground-level average concentration or total deposition values produced by emissions from multiple stack, volume and area sources. The ground level concentration or total deposition values can be calculated on a seasonal (monthly) or annual basis or both for an unlimited number of sources. The program is capable of producing the seasonal and/or annual results for each individual source input as well as for the combined (summed) seasonal and/or annual results from multiple groups of user-selected sources. The program calculations of concentration or deposition are performed for an input set of receptor coordinates defining a fixed receptor grid system and/or for discrete (arbitrarily placed) receptor points. The receptor grid system may be a right-handed Cartesian coordinate system or a polar coordinate system. In either case, zero degrees (north) is defined as the positive Y axis and ninety degrees (east) is defined as the positive X axis and all points are relative to a user-defined hypothetical origin (normally X=0, Y=0), although the Universal Transverse Mercator (UTM) coordinates may be used as the Cartesian coordinate system).

The ISCLT computer program is written in ANSI FORTRAN-77 and is designed to execute on most medium to large scale computers with minimal or no modifications. The program requires approximately 75,000 words (UNIVAC 1110) of executable core for instruction and data storage. The program design assumes a minimum of 32 bits per variable word and a minimum of four character bytes per computer word. The program also requires from two to four input/output devices, depending on whether the tape input/output options are used. Input card image data is referenced as logical unit 5 and print output, which requires 132-character print columns, is referenced as logical unit 6. The optional tape or data file input is referenced as logical unit 2 and the output is referenced as logical unit 3. The user has the option of either using the default logical unit numbers given here or specifying alternate logical unit numbers. The computer program consists of a main program (ISCLT) and 19 subroutines as shown in Appendix F. The FORTRAN source code for the entire model is given in Appendix B.

4.2.2 Data Deck Setup

The card image input data required by the ISCLT program depends on the program options desired by the user. The data may be partitioned into five major groups as shown in Figure 4-1. The five groups are:

1. Title Record (1 data card)
2. Program Option and Control Records (2 to 5 Records)
3. Receptor Data Records (the number of records included in this group depends on the parameters ISW(4), ISW(5), ISW(12), NXPNTS, NYPNTS and NXWYPT)
4. Meteorological Data (only if ISW(5) is less than or equal to 1)
5. Source Data Cards (this record group is included only if NSOURC is greater than zero)

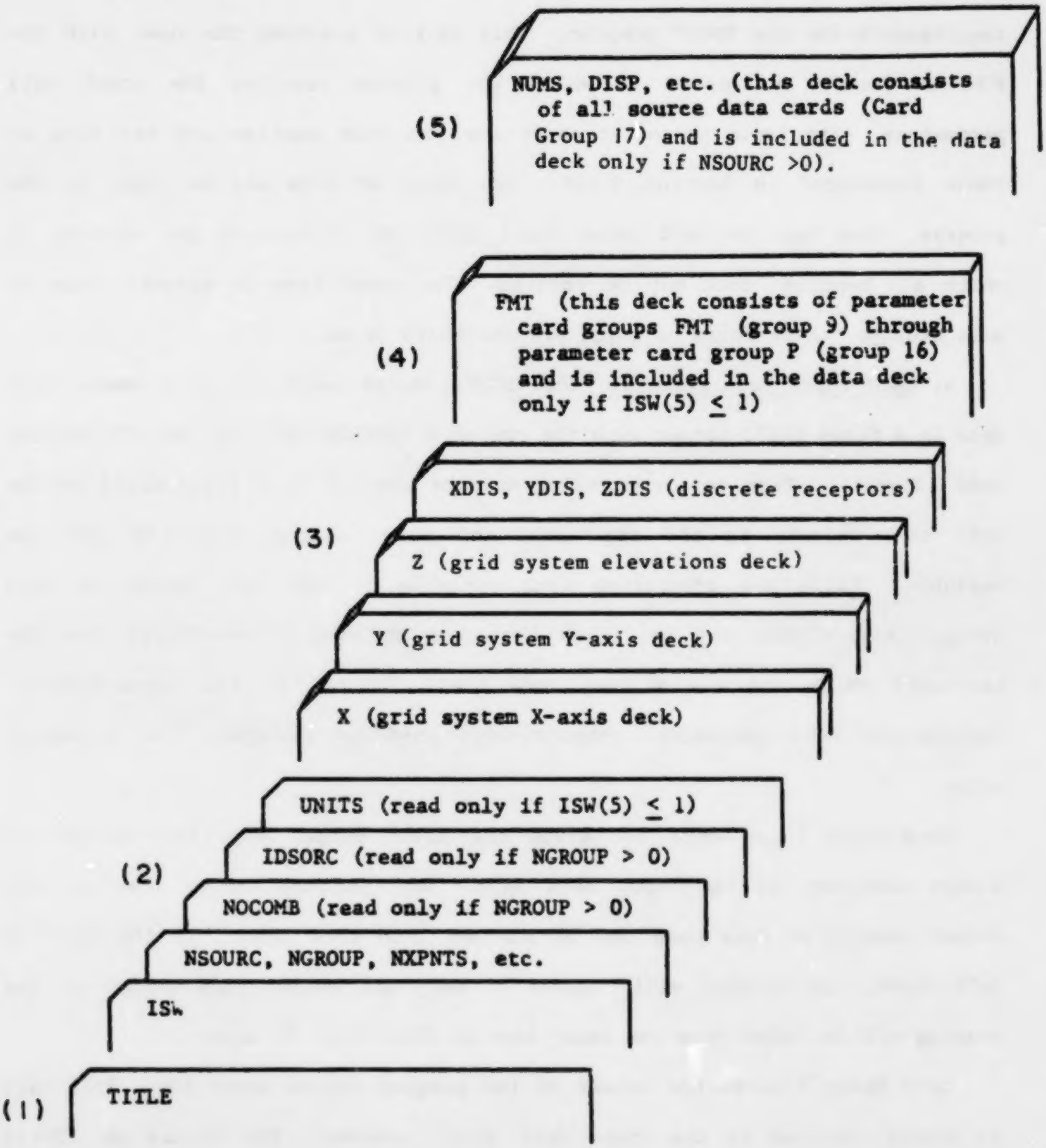

(5)
NUMS, DISP, etc. (this deck consists of all source data cards (Card Group 17) and is included in the data deck only if NSOURC >0).
(4)
FMT (this deck consists of parameter card groups FMT (group 9) through parameter card group P (group 16) and is included in the data deck only if ISW(5) ≤ 1)
(3)
XDIS, YDIS, ZDIS (discrete receptors)
Z (grid system elevations deck)
Y (grid system Y-axis deck)
X (grid system X-axis deck)
(2)
UNITS (read only if ISW(5) ≤ 1)
IDSORC (read only if NGROUP > 0)
NOCOMB (read only if NGROUP > 0)
NSOURC, NGROUP, NXPNTS, etc.
ISW
(1)
TITLE

FIGURE 4-1. Input data deck setup for the ISCLT program.

4.2.3 Input Data Description

Section 4.1.2 provides a summary description of all input data parameter requirements for the ISCLT program. This section provides the user with the FORTRAN format and order in which the program requires the input data parameters. The input parameter names used in this section are the same as those introduced in Section 4.1.2. Two forms of data may be input to the program. One form is card image input data (80 characters per record) in which all required data may be entered. The other form is magnetic tape or mass storage. Both forms of input are discussed below.

a. Card Input Requirements. The ISCLT program reads all card image input data in a fixed-field format with the use of a FORTRAN "A", "I" or "F" editing code (format). Each parameter value must be punched in a fixed-field on the data card defined by the start and end card columns specified for the variable. Table 4-4 identifies each variable by name and respective card group. Also, Table 4-4 specifies the card columns (fixed-field) for the parameter value and the editing code ("A", "I" or "F" for alpha-numeric, integer and real variables, respectively) used to interpret the parameter value.

Card Group 1 in Table 4-4 gives the print output page heading and is always included in the input data deck. Any information to identify the output listing or data case may be punched into this card. If the card is left blank, the heading will consist of only the output page number or the heading will be taken from the input tape or data file, if used.

Card Group 2 gives the values of the program option array ISW. This card is always included in the input data deck. However, the values of ISW(1) through ISW(4) are automatically set by the program if you are using an input (source/concentration or deposition inventory) tape. The options on this card that determine whether or not some card groups are included in the input data

TABLE 4-4

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
1	TITLE	1 - 80	20A4	80-character page heading label
2	ISW(1)*	2	I1	blank, 0 or 1 = calculate concentration 2 = calculate deposition
	ISW(2)*	4	I1	blank, 0 or 1 = Cartesian coordinate receptor grid 2 = polar coordinate receptor grid system
	ISW(3)*	6	I1	blank, 0 or 1 = Cartesian discrete (arbitrarily placed) receptors 2 = Polar discrete receptors
	ISW(4)*	8	I1	blank, or 0 = no terrain elevations data 1 = terrain elevation data in feet -1 = terrain elevation data in meters
	ISW(5)	10	I1	blank, or 0 = no input or output tape 1 = output tape only 2 = input tape only 3 = both input and output tapes
	ISW(6)	12	I1	blank, or 0 = input data are not printed 1 = print all but source input data 2 = print source input data only 3 = print all input data

* These parameters are set automatically by the program and cannot be changed if tape input (ISW(5) = 2 or 3) is being used.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2 (Cont.)	ISW(7)	14	I1	1 = print seasonal (monthly) calculations only 2 = print annual calculations only blank,0 or 3 = print both seasonal and annual calculations
	ISW(8)	16	I1	1 = print only concentration (deposition) from individual sources 2 = print only concentration (deposition) from combined sources blank,0 or 3 = print concentration (deposition) from both individual and combined sources
	ISW(9)	18	I1	1 = Urban Mode 1 2 = Urban Mode 2 blank,0 or 3 = Rural Mode if ISW(5) = 0 or 1 blank or 0 = Value from input tape if ISW(5) = 2 or 3 4 = Urban Mode 3
	ISW(10)	20	I1	blank or 0 = maximum 10 concentration (deposition) values are not calculated 1 = maximum 10 concentration (deposition) values are calculated according to ISW(11) or ISW(12) and only these calculations are printed

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2 (Cont.)	ISW(10)			2 = maximum 10 concentration (deposition) values are calculated according to ISW(11) or ISW(12) and these as well as the concentration (deposition) values at all other receptors are printed
	ISW(11)	22	I1	blank or 0 = see ISW(12) if ISW(10) > 0 1 = program determines maximum 10 of each individual source and source combination independently of each other 2 = program determines maximum 10 of combined sources and prints those as well as the contributions of each individual source to those receptors
	ISW(12)	24	I1	blank or 0 = see ISW(11) if ISW(10) > 0 1 = user specifies maximum 10 or special 10 receptors
	ISW(13)	25 - 26	I2	blank or 0 = print output goes to FORTRAN logical unit 6 (printer) n > 0 = print output goes to FORTRAN logical unit n followed by two end-of-file marks n < 0 = print output goes to FORTRAN logical unit n with no end-of-file marks
	ISW(14)	27 - 28	I2	blank or 0 = tape input data is read from FORTRAN logical unit 2 n > 0 = input data is read from magnetic tape on FORTRAN logical unit n n < 0 = input data is read from mass-storage on FORTRAN Logical unit n

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2 (cont.)	ISW(15)	29 - 30	I2	blank or 0 = tape output data is written to FORTRAN logical unit 3 (magnetic tape) n > 0 = output data is written to magnetic tape on FORTRAN logical unit n n < 0 = output data is written to mass storage on FORTRAN logical unit n
	ISW(16)	32	I1	blank or 0 = each new output table starts on a new page 1 = program minimizes number of output pages by not starting a new page even though successive tables are not related.
	ISW(17)	33 - 34	I2	blank or 0 = the program prints 57 lines per page before ejecting to a new page n > 0 = the program prints n lines per page before ejecting to a new page
	ISW(18)	35 - 36	I2	blank or 0 = the program reads Card Group 9a using a 6F10.0 format 1 = the program Card Group 9 which specifies the format the program is to use to read Card Group 9a
	ISW(19)	38	I1	blank or 0 = plume rise is independent of downwind distance 1 = plume rise is dependent on downwind distance

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
2 (cont.)	ISW(20)	40	I1	blank or 0 = no stack-tip downwash correction is made at the stack height 1 = the Briggs (1973) downwash correction is applied to the stack height
	ISW(21)	42	I1	0 = program uses buoyancy-induced dispersion 1 = program ignores buoyancy-induced dispersion
	ISW(22)	44	I1	0 = program uses a regulatory default mode 1 = program does not use a regulatory default mode
	ISW(23)	46	I1	0 = program assumes SO_2 is being modelled 1 = program assumes pollutant other than SO_2 is being modelled
	ISW(24)	48	I1	0 = program uses an input debug option. 1 = program does not use an input debug option.
3	NSOURC	1 - 4	I4	Number of card image input sources to be read under Card Group 17 to 17d below. If negative the program will continue to read Card Group 17 to 17d until a negative source ID-number is read from Card Group 17.
	NGROUP	5 - 8	I4	Number of different source combinations used to print concentration (deposition) calculations (the maximum is 20). If set to zero Card Groups 4 and 4a are omitted from the input card deck.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
	NXPNTS*	9 - 12	I4	Number of receptors in the X-axis of the receptor grid system. (The number of rings in polar coordinates).
	NYPNTS*	13 - 16	I4	Number of receptors in the Y-axis of the receptor grid system. (The number of radials in polar coordinates).
	NXWYPT	17 - 20	I4	Number of discrete (arbitrarily placed) receptor points. This parameter is not used if ISW(5) = 2 or 3 unless ISW(12) is non-zero.
	NSEASN*	21 - 24	I4	Number of seasons (months) in the input meteorological data. The maximum for this parameter is 4 and if blank or 0 the default is 1.
	NSPEED*	25 - 28	I4	Number of wind speed categories in the joint frequency of occurrence of wind speed and direction. The maximum is 6 and 6 is the default value if blank or 0.
	NSTBLE*	29 - 32	I4	Number of Pasquill stability categories in the joint frequency or occurrence of wind speed and direction. The maximum is 6 and the default is 6 if blank or 0.

*These parameters are set automatically by the program and cannot be changed if tape input (ISW(5) = 2 or 3) is being used.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
3	NSCTOR*	33 - 36	I4	Number of wind direction sector categories in joint frequency of occurrence of wind speed and direction. The maximum is 16 and the default is 16 if blank or 0.
	NOFILE	37 - 40	I4	Output file number of output tape or if no output tape, then input file number of input tape. Applicable to magnetic tape only, when Condition a or Condition b is being used under ISW(11) or NGROUP.
4	NOCOMB	1 - 4 5 - 8 . . . 77 - 80	20I4	Array used to specify the number of Source ID-numbers you are using to define each source combination. There are NGROUP values read here. This data card is omitted from the input card deck if NGROUP = 0.
4a	IDSORC	1 - 6 7 - 12 . . . 73 - 78 (for each card)	13I6	Array used to specify the source ID-numbers to use in forming the combined source output and individual source output. There is a maximum of 200 values that can be input here. This data card group is omitted from the input card deck if NGROUP = 0.

---

* These parameters are set automatically by the program and cannot be changed if tape input (ISW(5) = 2 or 3) is being used.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
5**	UNITS	1 - 40	10A4	40 characters giving the concentration (deposition) print output units. This label is automatically filled if the parameter TK on Card Group 13 is defaulted. If this label is punched, start in Column 1.
		41 - 80	10A4	40 characters giving the source strength input units. This label is automatically filled if the parameter TK on Card Group 13 is defaulted. If this label is punched, start in column 41. This card group is omitted from the input deck if tape input (ISW(5) = 2 or 3) is being used.
6**	X	1 - 10 11 - 20 . . . 71 - 80 (for each card)	8F10.0	Array of NXPNTS receptor points in meters in ascending order defining the X-axis of the receptor grid system or the distances to the rings in polar coordinates. If only two values are punched and NXPNTS is greater than 2, the program assumes the first is the start of the axis and the second is the increment used to generate the remaining points. This card group is omitted from the input data deck if NXPNTS = 0.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
7**	Y	1 - 10 11 - 20 . . . 71 - 80 (for each card)	8F10.0	Array of NYPNTS receptor points in meters or degrees, depending on ISW(2), in ascending order defining the Y-axis of the receptor grid system or the radials in polar coordinates. If only two values are punched and NYPNTS is greater than 2, the program assumes the first is the start of the axis and the second is the increment used to generate the remaining points. This card group is omitted from the input data deck if NYPNTS = 0. (in feet if ISW(4) = 1, meters if ISW(4) = -1)
8**	Z	1 - 10 11 - 20 . . . 71 - 80 (for each card)	8F10.0	Array of terrain elevations for each receptor of the NXPNTS by NYPNTS grid system. This card group is omitted from the input data deck if either ISW(4) = 0 or an input tape is being used. See the text for the order of values input to this card group.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
6a,7a,8a**	X,Y,Z Discrete	1-10 11-20 21-30	3F10.0	X is the location along the X-axis, or the distance to a ring in polar coordinates, of a discrete receptor. Y is the location along the Y-axis, or the radial in polar coordinates, of a discrete receptor. Z is the elevation units (depending on ISW(4)) of a discrete receptor. Each card should contain all the information for 1 discrete receptor. If terrain elevations are not to be considered, leave the last entry on each card blank. These card groups are not entered if NXWYPT = 0, or an input tape is being used and ISW(12) = 0.
9**	FMT	1 - 80	20A4	Array specifying the format used to read Card Group 9a (not read if ISW(18) = 0, default format is 6F10.0).
9a**	FREQ	1 - 10*** 11 - 20 . . . 51 - 60 (for each card)	FMT	Array giving the joint frequency of occurrence of the wind speed and direction for each stability category and each season expressed as a percentage or as a fraction. See the text for the order of input values.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

*** These are default card columns used for this array and are not applicable if FMT on Card Group 9 is input.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
10**	TA	1 - 10 11 - 20 . . . 51 - 60 (for each card)	6F10.0	Array of ambient air temperatures in degrees Kelvin as a function of stability category and season. See the text for the order of input values.
11**	HM	1 - 10 11 - 20 . . . 51 - 60 (for each card)	6F10.0	Array of mixing layer heights in meters as a function of wind speed and stability category and season. See the text for the order of input values.
12**	DPDZ	1 - 10 11 - 20 . . . 51 - 60 (for each card)	6F10.0	Array of the vertical gradient of potential temperature in degrees Kelvin per meter as a function of wind speed and stability category. See the text for the order of input values.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
13**	ROTATE	1 - 10	F10.0	Wind direction correction parameter used to correct for any difference in north as defined by the reference receptor grid system and north as defined by the weather station at which the weather data were recorded. The value of ROTATE is subtracted from each wind direction category.
	TK	11 - 20	F10.0	Model units conversion factor used to produce the desired output concentration (deposition) units from the input source strength units. The concentration default for TK is 1×10^6 micrograms per gram assuming output in micrograms per cubic meter and input source units in grams per second per square meter for area sources. The deposition default for TK is 1 assuming output in grams per square meter and input source units in total grams for stack and volume sources and grams per square meter for area sources.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
13** (cont.)	TK (Cont.)			If the default is chosen, the parameter UNITS above on Card Group 5 is automatically set.
	ZR	21 - 30	F10.0	Height in meters above ground at airport or weather station at which the wind speed was measured. The default value is 10.0 meters.
	G	31 - 40	F10.0	Acceleration due to gravity in meters per second squared. The default is 9.8 m/sec^2.
	DECAY	41 - 50	F10.0	Coefficient (seconds^{-1}) of time dependent pollutant removal by physical or chemical processes. Default is zero or no decay.
14**	UBAR	1 - 10 11 - 20 . . . 51 - 60	6F10.0	Array containing the median value of each wind speed category in meters per second. The default values are 1.5, 2.5, 4.3, 6.8, 9.5, and 12.5 m/sec for the standard STAR summary wind-speed categories.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
15**	THETA	1 - 10 11 - 20 . . . 71 - 80 (for each card)	8F10.0	Array of wind direction sector angles in degrees beginning with the first direction category used in the joint frequency of occurrence of wind speed and direction (normally zero degrees north). NSCTOR values are read and, if the first two values are zero this array is defaulted to the standard direction angles 0.0, 22.5, 45.0, ..., 337.5 degrees.
16**	P	1 - 10 11 - 20 . . . 51 - 60 (for each card)	6F10.0	Array of wind speed power law exponents as a function of wind speed and stability categories. See the text for the order of values and default values.
17	NUMS	1 - 5	I5	Source identification number. Input all sources in ascending order of the identification number. If the number is negative, source input is terminated. If this number is zero, the program defaults the relative position of this source in the source input deck. Card Groups 17 through 17d are omitted from the input data deck if NSOURC equals zero. Remember to group Card Groups 17 through 17d together as a set for each input source.

** These card groups are omitted from the input card deck if tape input (ISW(5) = 2 or 3) is being used. The information for these parameters is taken from the input tape.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
17 (Cont.)	DISP	6	I1	Source disposition blank or 0 = new input source or replace old source if it has same ID-number 1 = delete incoming tape source with same ID-number (next card group read is 17) 2 = rescale concentration (deposition) values for this source using input source strengths (next card group read is 17d) (only if QFLG = 0)
	TYPE	7	I1	Source type. blank or 0 = stack 1 = volume 2 = area
	QFLG	8	I1	Source emissions variation flag. blank or 0 = source emission varies with season (month) only 1 = source emission varies with stability category and season 2 = source emission varies with wind speed category and season 3 = source emission varies with wind speed and stability category and season

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
	DX	9 - 18	F10.0	Cartesian X-coordinate of the source in meters, (source center for building and stack sources and southwest corner for area sources)
	DY	19 - 28	F10.0	Cartesian Y-coordinate of the source in meters, (source center for building and stack sources and southwest corner for area sources)
	H	29 - 35	F7.0	Height above the ground of the emission in meters
	ZS	36 - 42	F7.0	Elevation in meters above mean sea level at the source location.
	TS or SIGYO or XO	43 - 49	F7.0	This field depends on the source type -- if TYPE = 0, TS = stack gas exit temperature in degrees Kelvin TYPE = 1, SIGYO = standard deviation of the crosswind source distribution in meters. TYPE = 2, XO = width of the area source in meters.
	VEL or SIGZO	50 - 56	F7.0	This field depends on the source type -- if TYPE = 0, VEL = stack gas exit velocity in meters per second TYPE = 1, SIGZO = standard deviation of the vertical source distribution in meters TYPE = 2, this field is left blank

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS, FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
	HB	64 - 70	F7.0	This field depends on the source type -- if TYPE = 0, HB = 0, wake effects are not considered for this source HB > 0, height above ground in meters of the building adjacent to the stack for the consideration of wake effects for this source TYPE = 1 or 2, this field is left blank
17	BW	71 - 77	F7.0	This field depends on the source type -- if TYPE = 0, BW = 0, wake effects are not considered for this source BW > 0, width of the building in meters adjacent to the stack for the consideration of wake effects for this source TYPE = 1 or 2, this field is left blank

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
17 (Cont.)	WAKE	78	I1	This field depends on the source type -- if TYPE = 0, WAKE is a super squat building wake effects equation option. If the building width to height ratio is greater than 5 and WAKE is blank, or 0, the program uses the equation of lateral virtual distance (Equation (2-31) that will produce the upper bound of concentration or deposition. If WAKE is 1, the equation of lateral virtual distance (Equation (2-33)) that will produce the lower bound of the concentration or deposition calculation is used (see Section 2.4.1.1.d) TYPE = 1 or 2, this field is left blank
	NVS	79 - 80	I2	Number of particulate size categories in the particulate distribution for deposition or concentration width depletion due to dry deposition. The maximum value of this parameter is 20.
17a	VS	1 - 10 11 - 20 . . 71 - 80 (for each card)	8F10.0	Array of settling velocities in meters per second for each particulate size category. This card group is omitted from the input data deck if NVS = 0.

TABLE 4-4
(Cont.)

ISCLT PROGRAM CARD INPUT PARAMETERS,
FORMAT AND DESCRIPTION

Card Group	Parameter Name	Card Columns	FORTRAN Edit Code (Format)	Description
17b	FRQ	1 - 10 11 - 20 . . 71 - 80 (for each card)	8F10.0	Array of mass fraction of the particulate distribution for each category. The sum of the fractions in this array should total 1 (100% of the distribution). This card group is omitted from the input data deck if NVS = 0.
17c	GAMMA	1 - 10 11 - 20 . . 71 - 80 (for each card)	8F10.0	Array of surface reflection coefficients (fraction, 0 to 1) for each particulate size category. A value of 0 is no reflection; a value of 1 is complete reflection. This card group is omitted from the data deck if NVS = 0.
17d	Q	1 - 10 11 - 20 . . 51 - 60 (for each card)	6F10.0	Array of source emissions in units indicated by the parameters UNITS and TK above. The number of values input in this card group is determined by QFLG on Card Group 17 and the order of input is given in the text. This card group is omitted from the input data deck if DISP on Card Group 17 equals "1".

deck are: ISW(4), ISW(5), ISW(12), and ISW(18). If ISW(4) is left blank or punched zero, Card Groups 8 and 8a are omitted from the input data deck. If ISW(5) is equal to "2" or "3" (indicating an input data tape), Card Groups 5, 6, 7, 8, and 9 through 16 are omitted from the input data deck. Also, Card Groups 6a, 7a, and 8a are omitted if the ISW(12) option is not used or equals blank or zero. If ISW(18) is left blank or punched zero, Card Group 9 is omitted from the input card deck. The ISW(10) option on this card must be set to "1" or "2" if either the ISW(11) or ISW(12) option is chosen. Note the conditions on ISW(11) given in Section 4.1.2. Also, the option ISW(9) must always be set correctly when card input sources are used or if tape sources are used when ISW(12) equals "1."

Card Group 3 contains the parameters that specify the number of input sources, size of receptor arrays and the number of categories in the input meteorological data. These parameters are regarded as options because, if any are zero, a particular function is not performed. All of the parameters on this record except NOFILE may alter the form of the input deck because they specify how many data items to input to the program. The parameter NSOURC specifies how many times the program is to read Card Groups 17 through 17d. If NSOURC is set to a negative value ("-1"), the program will continue to read source data from Card Groups 17 through 17d until a negative source ID-number (NUMS) is read from Card Group 17. If NSOURC is zero, Card Groups 17 through 17d are omitted from the input data deck. The parameter NGROUP is used to group selected sources into a combined output by summing the concentration or deposition arrays of the selected sources. The user may specify up to a maximum of 20 different source combinations. If NGROUP is left blank or punched zero, the program uses all sources in any combined source output, prints all sources for any individual source output, and Card Groups 4 and 4a are omitted from the input card deck. If NGROUP is greater than zero, it specifies how many values are to be read from Card Groups 4 and 4a. Also NGROUP cannot be set to a non-zero value unless one or more of the specified conditions in Section 4.1.2 are met.

Card Groups 4 and 4a always occur together and are included in the input card deck only if NGROUP is greater than zero. Card Group 4 is the array NOCOMB used to specify the number of source ID-numbers used to define each source combination. Each value in NOCOMB specifies the number of source ID-numbers to be read from Card Group 4a (IDSORC) in consecutive order for each source combination. A positive source ID-number punched into the array IDSORC indicates to include that source in the combination. A negative source ID-number indicates to include that source as well as all source ID-numbers less in absolute value, up to and including the previous positive source ID-number punched if it is part of the same set of ID-numbers defining a combination. If the negative value is the first ID-number of a group of ID-numbers, it as well as all sources less in absolute values of ID-number are included in the source combination. See the example given under NOCOMB and IDSORC in Section 4.1.2 and the example problems in Appendix D.

Card Group 5 is an array (UNITS) used to specify the labels printed for concentration or deposition output units and for the input source strength units. This card group is omitted from the input card deck if tape or data file input is used.

Card Groups 6 through 8a specify the X, Y and Z coordinates of all receptor points. Card Groups 6, 7 and 8 are omitted from the input card deck if the parameters NXPNTS and NYPNTS equal zero or if an input tape is being used. Also, Card Group 8 is omitted if ISW(4) equals "0" (no terrain elevations are being used.) Card Groups 6a, 7a and 8a are also omitted from the input card deck if the parameter NXWYPT is zero or if an input tape is being used with ISW(12) equal to "0." Each of these card groups uses a 10 column field. The number of data cards required for each card group is defined by the values of the parameters NXPNTS, NYPNTS and NXWYPT. Values input on Card Groups 6 and 7 are always in ascending order (west to east, south to north, 0 to 360 degrees). The terrain elevations for the grid system on Card Group 8 begin in the southwest corner of the grid system or at 0 degrees for polar coordinates. The first data card(s) contain the elevations for each receptor on the X axis (1 to NXPNTS) for the first Y receptor coordinate. A new data card is started for the elevations for each successive Y receptor coordinate. A total of NYPNTS groups of data cards containing NXPNTS values each is required for Card Group 8. See the discussion given for parameter Z in Section 4.1.2.b for examples of the order of input for receptor elevations in Cartesian and polar systems.

Card Groups 9 through 16 specify the meteorological data and model constants and are included in the input data deck only if an input tape or data file is not being used. Card Group 9 is input only if ISW(18) equals "1" and specifies the format (FMT) which the program uses to read the card data in Card Group 9a. If Card Group 9 is omitted from the input deck (ISW(18) equals "0"), the program assumes the format is (6F10.0) or there are 6 values per card occupying 10 columns each including the decimal point (period). Card Group 9a is the set of data cards giving the joint frequency of occurrence of the wind speed and wind direction (FREQ) by season and Pasquill stability category. The values for each wind speed category (1 to NSPEED) are punched across the card and are read using the format given in Card Group 9 or the default format used when Card Group 9 is omitted. The first card is for direction category 1 (normally north), the second card for direction category 2 (normally north-northeast), down to the last direction category (normally north-northwest). Starting with season 1 (normally winter), the card group contains a set of these (NSCTOR) cards for each stability category, 1 through

NSTBLE. The program requires NSCTOR•NSTBLE•NSEASN data cards in this card group. This data deck is normally produced by the STAR program of the National Climatic Data Center (NCDC).

Card Group 10 is the average ambient air temperature (TA). NSTBLE values are read from each data card in this group, and there is one data card for each season, 1 through NSEASN. Card Group 11 is the median mixing layer height (HM) for each speed and stability category and season. The program requires NSPEED values per data card and one data card for each stability category, 1 to NSTBLE. A group of these cards is required for each season (1 to NSEASN) for a total of NSTBLE•NSEASN data cards in Card Group 11. Card Group 12 is the vertical gradient of potential temperature (DPDZ) for each wind speed and stability category. NSPEED values are punched across the card and NSTBLE cards (1 to NSTBLE) are punched for this group. Card Group 13 contains meteorological and model constants; a detailed description of these parameters (ROTATE, TK, ZR, G and DECAY) is given in Section 4.1.2 above. Card Group 14 is the median wind speed for each wind speed category (UBAR) and there are NSPEED values read from this card group. Card Group 15 is the median wind direction for each wind direction category (THETA). There are 8 values read from each data card in this group up to a maximum of NSCTOR (normally 16) values. Card Group 16, the last of the meteorological input card groups, provides the wind speed power law exponents (P) for each wind speed and stability category. There are NSPEED values read per data card and NSTBLE (1 to NSTBLE) cards read in this group.

The last card groups in the input data deck, Card Groups 17 through 17d, consist of source related information. Card Groups 17 through 17d are always input as a set of cards for each individual source and each of these sets (17 through 17d are input in ascending order of the source ID-number (NUMS). Card Group 17 provides the source ID-number (NUMS), the source type (TYPE), the source disposition (DISP), etc. This data card is included in the input card deck for each card input source, 1 to NSOURC. As shown in Table 4-4, some of the card columns (43 through 78) on this card may or may not contain parameter values, depending on the source type. The last parameter (NVS) on this card determines whether Card Groups 17a through 17c are read or not. These card groups are not included in the input deck if NVS equals zero. The last card group, Card Group 17d, contains the source emissions (Q). This card group is not included in the input data deck if the parameter DISP on Card Group 17 equals "1." The number of cards and values in this card group depends on the parameter QFLG on Card Group 17. If QFLG equals blank or zero, the source emissions are a function of season only and one data card is read with NSEASN values punched across it. If QFLG is equal to "1," the program assumes the source emissions are a function of stability category and season. In this case, NSEASN data cards (1 through NSEASN) are required with NSTBLE values per card. If QFLG is equal to "2," the program assumes the source emissions are a function of wind speed and season. There are NSEASN data cards read with NSPEED values per card. If QFLG is equal to "3," the program assumes the source emissions are a function of wind speed, stability and season. In this last case, the program reads NSTBLE data cards containing NSPEED values for each season (1 to NSEASN) for a total of NSTBLE*NSEASN data cards. The program continues to read sets of data Card Groups 17 through 17d until a negative source ID-number is encountered or until it has read these cards NSOURC times.

b. Disc or Tape File Input Requirements. The ISCLT program can accept a source inventory file previously created by the ISCLT program. This is a binary file written using the FORTRAN I/O routines and created on a previous run of the ISCLT program. This file contains all of the program options that affect how the model concentration or deposition calculations were performed (except ISW(9)), all of the receptor and elevation data, all of the meteorological data, all of the source input data and the results of the seasonal (annual) concentration or deposition calculations at each receptor point. The program reads the data from the FORTRAN logical unit number specified by ISW(14). The tape data are read only if option ISW(5) equals "2" or "3." The input file requires the user to omit specified data card groups from the input deck and makes the input of some parameter values unnecessary. The omitted Card Groups and unnecessary parameters are indicated by a * or ** in the Card Group and Parameter Name columns of Table 4-4. The format and exact contents of the input file are discussed in Section 4.2.4.b below.

4.2.4 Program Output Data Description

The ISCLT program generates several categories of printed output and an optional output source/concentration or deposition inventory tape (or data file). The following paragraphs describe the format and content of both forms of program output.

a. Printed Output. The ISCLT program generates 11 categories of printed output, 8 of which are tables of average ground-level concentration or total ground-level deposition. All program printed output is optional except warning and error messages. The printed output categories are:

- Input Source Data
- Input Data other than Source Data
- Seasonal Concentration (Deposition) from Individual Sources
- Seasonal Concentration (Deposition) from Combined Sources
- Annual Concentration (Deposition) from Individual Sources
- Annual Concentration (Deposition) from Combined Sources
- Seasonal Maximum 10 Concentration (Deposition) Values from Individual Sources

- Seasonal Maximum 10 Concentration (Deposition) Values from Combined Sources
- Annual Maximum 10 Concentration (Deposition) Values from Individual Sources
- Annual Maximum 10 Concentration (Deposition) Values from Combined Sources
- Warning and Error Messages

The first line of each page of output contains the run title (TITLE) and the page number followed by the major heading of the type or category of output table.

The example output shown in Appendix D is generated from the example given in Section 2.6. The tables are defined by their respective headings and are all optional, depending on the parameters ISW(7), ISW(8), ISW(10), and ISW(11) or ISW(12). Also, the ISCLT program has an option (ISW(16)) of compressing the output tables by minimizing the number of new pages started by new tables. This option will save on the paper output, but the user should become familiar with the program output format before using it. Also, the program has the option (ISW(17)) of specifying the number of lines the printer prints per page. This value must be correct in order for the program to maintain a correct output format. The program defaults to 57 lines per printed page. If the printer at your installation is different, input the correct value into ISW(17) on Card Group 2. The warning and error messages produced by the program are generated by data errors within the ISCLT program and are not associated with errors detected by the computer system on which the program is being run. These errors are given in Section 4.2.6 below.

b. Master File Inventory Output. The ISCLT program will, on option, generate an output master source/concentration or deposition inventory file. This file is written only if the parameter ISW(5) equals "1" or "3" and the data are written in binary to the FORTRAN logical unit specified by ISW(15).

The format and contents of the ISCLT input/output tape are shown in Table 4-5. This table gives the Logical Record, Word Number, Parameter Name and whether the data are in an integer or floating point (real) format. The logical record gives the order the respective data records are written to tape. Some of the logical records shown in Table 4-5 may or may not be present on the tape, depending on the options ISW(4) and NSEASN. Logical record 4 is not on the tape if the parameter ISW(4) is zero. Also, records 7 through 10 are concentration or deposition records and depend on the number of seasons, NSEASN. If the user is using annual data, only record 7 out of records 7 through 10 will be on the tape. Records 6 through 10 are written to the tape for each source input to the program. The last record written for a program run has an integer 999999 in word 1 (NUMS) of the record and two end of file marks (magnetic tape only) are written after this record.

4.2.5 Page and Tape Output Estimates

This section gives approximations to the tape output and page output for the ISCLT program. Because of the variability of problem runs and input parameters, the equations in this section are meant only to give an approximation of the upper limit of the page or tape usage function.

a. Page Output. The total number of pages of output from the ISCLT program depends on the problem being run and is given by:

$$\text{Pages} = \underline{A} + \underline{B} + \underline{C} \qquad (4\text{-}4)$$

where*

$\underline{A}$ = 0 ; if the program input data is not printed

or

16 ; if input data other than source data is printed (ISW(6) = "1")

---

*The [] symbols indicate to round up to the next largest integer if there is any fractional part.

TABLE 4-5

INPUT/OUTPUT TAPE FORMAT

Tape Logical Record	Relative Word Number	Parameter Name	Integer (I)/ Floating Point (FP)
1	1	NSOURC	I
	2	NXPNTS	I
	3	NYPNTS	I
	4	NXWYPT	I
	5	NSEASN	I
	6	NSPEED	I
	7	NSTBLE	I
	8	NSCTOR	I
	9 - 32	ISW	I
	33 - 52	UNITS	I
	53 - 72	TITLE	I
2	1 - NXPNTS+NXWYPT	X	FP
3	1 - NYPNTS+NXWYPT	Y	FP
4*	1 - NXPNTS*NYPNTS +NXWYPT	Z	FP
5	1 - 2304	FREQ	FP
	2305 - 2328	TA	FP
	2329 - 2472	HM	FP
	2473 - 2508	DPDZ	FP
	2509 - 2514	UBAR	FP
	2515 - 2550	P	FP
	2551 - 2566	THETA	FP
	2567	ROTATE	FP
	2568	G	FP
	2569	ZR	FP
	2570	DECAY	FP
	2571	TK	FP

***Tape logical record 4 is on the tape only if the parameter ISW(4) is non-zero.**

TABLE 4-5
(Cont.)

INPUT/OUTPUT TAPE FORMAT

Tape Logical Record	Relative Word Number	Parameter Name	Integer (I)/ Floating Point (FP)
6**	1	NUMS	I
	2	TYPE	I
	3	DX	FP
	4	DY	FP
	5	H	FP
	6	ZS	FP
	7	TS	FP
	8	VEL	FP
	9	D	FP
	10	HB	FP
	11	BW	FP
	12	BL	FP
	13	NVS	I
	14 - 33	VS	FP
	34 - 53	FRQ	FP
	54 - 73	GAMMA	FP
	74 - 217	Q	FP
	218	QFLG	I
	219	WAKE	I
7**	1 - NXPNTS*NYPNTS +NXWYPT	CON	FP
8**	1 - NXPNTS*NYPNTS +NXWYPT	CON	FP
9**	1 - NXPNTS*NYPNTS +NXWYPT	CON	FP
10**	1 - NXPNTS*NYPNTS +NXWYPT	CON	FP
last	1	999999	I

**Records 6 through 10 are repeated for each source input to the program and 8 through 10 are omitted if the input data is annual.

or

N_s ; if source data only is printed (ISW(6) = "2")

or

$16 + N_s$; if all input data is printed (ISW(6) = "3") and (ISW(4) = "0"), no terrain data

or

$16 + N_s + [N_x/9]\ [N_y/(N_\ell - 19)]\ [N_{xy}/(3\ (N_\ell - 11))]$ if

all input data is printed (ISW(6) = "3") and (ISW(4) = "1" or "-1") terrain data are used

N_s = total number of sources input to the program. However, if concentration or deposition from individual sources is not being printed (ISW(8) = "2") use $N_s = [N_s/4]$

N_ℓ = Number of print lines per page (ISW(17)), default is 57.

$$\underline{B} = I\ (N_i + N_c)\ (N_x/9)\ (N_y + 11)/N_\ell + N_{xy}/(3\ (N_\ell - 11)) + K \quad (4\text{-}5)$$

I = number of seasons for which concentration or deposition is to be printed. If seasonal output only, then I = NSEASN; if annual output only, then I = 1; if both seasonal and annual output, then I = NSEASN+1.

N_i = total number of individual source concentration or deposition tables being printed. If ISW(8) equals "2", then N_i is set to zero. If ISW(8) equals "1" or "3", then N_i is the total number of source ID-numbers defined under the parameter IDSORC. This includes both implied and explicitly punched source ID-numbers in IDSORC. Count each source ID-number only once. If the parameter NGROUP is "0" and the array IDSORC is not input, then N_i is the total number of card plus tape input sources. Also, if maximum 10 calculations are being made via ISW(11) or ISW(12), add N_i pages to the total pages in Equation (4-5) above for the individual source contributions to the combined maximum 10.

N_c = total number of combined source concentration or deposition tables being printed (NGROUP). Do not count single sources if they are already counted in N_i.

N_x = NXPNTS

N_y = NYPNTS

N_{xy}= NXWYPT

K = 0; if maximum 10 values are not printed (ISW(10) = 0)
or
1; if maximum 10 values are printed (ISW(10) > 0)

C = the number of pages expected from the system plus other processing within the job

The above equations may not cover every option in the ISCLT program and, if the system the user is using aborts runs that max-page, be generous with the page approximation.

b. Tape Output. The total amount of tape used by a problem run depends on the type of computer, the installation standard block length for unformatted FORTRAN records, the number of tape recording tracks, the tape recording density and the options and data input to the problem run. This section provides the user with the total number of computer words output to tape or data file and an approximation to the tape length used in feet.

The total number of computer words output to tape is given by

$$\text{Words} = (I + 2647 + N_x + N_y + 2N_{xy} + N_s\,(220 + N_{se}(N_x \bullet N_y + N_{xy}+1))) \qquad (4\text{-}6)$$

where

$$I = \begin{cases} 0 & ;\ \text{if option ISW(4)} = 0 \\ \text{or} & \\ N_x \bullet N_y + N_{xy}+1; & \text{if option ISW(4)} = 1 \text{ or } -1 \end{cases}$$

N_s = the total number of card and/or tape input sources

N_{se}= the number of seasons, NSEASN

N_x = NXPNTS

N_y = NYPNTS

N_{xy}= NXWYPT

Add 28 to the total number of words written for UNIVAC 1100 series computers.

The user can approximate the length of tape required by

$$\text{Length (feet)} \simeq [(\text{ Words} \bullet B)/(B_y \bullet D) + .75\ \text{Words}/B_{\ell} + 6.0]/12.0 \qquad (4\text{-}7)$$

where

B = the number of bits per computer word. IBM 360, etc. is 32, UNIVAC 1100 series is 36 and CDC 6000 series is 60.

D = the tape recording density chosen by the user or required by the I/O device, 200, 556, 800 or 1600 bpi.

B_ℓ = the number of words per physical tape block for unformatted FORTRAN records on the user's computer system. Use 224 for UNIVAC 1100 series computers.

B_y = "6" for 7 track tape or "8" for 9 track tape

The values 0.75 and 6.0 inches are used assuming the interrecord gap is 0.75 and the end-of-file is 6 inches.

4.2.6 Program Diagnostic Messages

The diagnostic messages produced by the ISCLT program are associated only with data and processing errors within the program and should not be confused with those produced by the computer system on which the ISCLT program is run. All messages begin with either the word ERROR or the word WARNING. All ERROR messages terminate the execution of the program and WARNING messages allow the program to continue. However, WARNING messages could indicate data errors and should be examined thoroughly when they occur. A list of the messages are given in Table 4-6 with the probable cause of the respective message.

4.2.7 Program Modifications for Computers other than UNIVAC 1100 Series Computers

The ISCLT program is written in the FORTRAN language and uses the FORTRAN features compatible with standard ANSI FORTRAN. The program can be implemented on most computers that meet the following requirements:

- Must have the equivalent of 75,000 UNIVAC 1110 words of executable core storage
- Must use 32 or more bits per computer word

- Must use 4 or more characters (bytes) per computer word
- Must allow object time dimensioning (FORTRAN)
- Must have a 132 column line printer

The program also assumes the input card device is logical unit 5, the output printer is logical unit 6, the input tape unit is logical unit 2 and the output tape unit is logical unit 3. However, all but unit 5 can be overridden with an alternate unit number by input option. If the user must change unit 5 to an alternate number for the card input device, the variable IUNT in the main program must be changed. This variable appears after the input comments section in the FORTRAN listing of the main program.

The user may also adjust the computer core required by the program by reducing or increasing the dimension (size) of BLANK COMMON in the program. This is the first statement in the main program and, if changed, the user must also change the value of the variable IEND in the main program. The variable IEND appears after the input comments section in the main program. Also, the user must change the value of E in Equations (4-1), (4-2) and (4-3) in the body of this text. Program capabilities can be limited if the size of BLANK COMMON is reduced.

It is not possible to give all changes required to implement this program on all computers. However, changes necessary to implement this program on IBM and CDC medium to large scale computers are given below:

Changes required for use on IBM 360 or above computers:

- Change the call ACOS to ARCOS in subroutine DISTR

Changes required for use on CDC 6000 or above series computers:

- Add the following line on the first line of the main program

```
PROGRAM ISCLT (INPUT, OUTPUT, TAPEnn, TAPEmm)
```

TABLE 4-6

ISCLT WARNING AND ERROR MESSAGES

---

1. ERROR - MAX STORAGE = n, USER REQUESTED m REDUCE NO. OF CALC. POINTS. The program execution is terminated because the run required n locations of BLANK COMMON and only m are available. See Equation (4-1) in Section 4.1.2 for the core usage equation. See, also, Equations (4-2) and (4-3) that may place additional restrictions on the user.

2. ERROR - NUMBER OF SETTLING VELOCITIES FOR SOURCE n IS ZERO. Deposition is being calculated and the parameter NVS on Card Group 17 is zero for source n. Set NVS to the number of settling velocity categories and rerun.

3. WARNING - FREQ. OF OCCURRENCE OF SPD VS. DIR IS NOT 1.0 FOR SEASON n, PROG DIVIDES BY xxx.x TO NORMALIZE. The sum over all categories of the joint frequency of occurrence of wind speed and wind direction for season n is not exactly 1.0 and the program normalizes the frequency distribution by the factor xxx.x; execution continues.

4. WARNING - DISTANCE BETWEEN SOURCE n and POINT X, Y = xx.x, yy.y IS LESS THAN PERMITTED. This is a warning message to inform the user that the program attempted to calculate concentration or deposition at the point xx.x, yy.y for source n, but the distance is less than the model allow and no calculations were made, but execution continues. The user should ignore calculations at xx.x, yy.y for source n or any source combination including source n.

5. ERROR - DISP CANNOT EQUAL 2 WHEN QFLG IS GREATER THAN 0, OFFENDING SOURCE = n, PROG. TERMINATED. An attempt was made to rescale concentrations that do not vary only by season. The program saves only seasonal concentration on tape and cannot rescale with source strengths that vary by wind speed and/or stability. Input all of the source data via card setting DISP equal to zero and NUMS equal to the respective tape input source ID-number. The tape source will be replaced by the card source.

6. ERROR - DISP GREATER THAN 0 FOR SOURCE n, NO MORE TAPE SOURCES, PROG. TERMINATED. The program has found a source input card (Card Group 17) that indicates it is to update or delete a tape source, but it has run out of tape sources. Check your input source deck and make sure you have the correct input tape.

7. ERROR - DISP GREATER THAN 0 FOR SOURCE n, CANNOT FIND CORRESPONDING TAPE SOURCE, PROG. TERMINATED. The program has found an input source card (Card Group 17) that indicates it is to update or delete source n, but that source is not on the tape. Check the sequence of the input source data as they must be in ascending order of the source ID-number. Also, make sure you have the correct input tape.

TABLE 4-6
(Cont.)

ISCLT WARNING AND ERROR MESSAGES

---

8. WARNING - HW/HB > 5 FOR SOURCE n, PROG. USES LATERAL VIRTUAL DIST. FOR UPPER BOUND OF CONCENTRATION (DEPOSITION). The program is informing the user that the supersquat building wake effects option (WAKE) on Card Group 17 was set to blank, "0" and the program defaulted to those equations for the lateral virtual distance that produce the upper bound on the concentration or deposition. The lower bound may be calculated in another run by setting WAKE = 1.

9. ERROR - AVAILABLE CORE = n, PROBLEM REQUIRES m OR MORE LOCATIONS. The program has determined that m locations of BLANK COMMON are requires for the run, but only n locations are available. See Equations (4-1), (4-2) and (4-3) in Section 4.1.2.

10. ERROR - MAX. NO. OF SOURCES EXCEEDED FOR NGROUP OF ISW(11) = 2 OPTION. The number of sources the program has input exceeds the number the program is capable of processing under the special condition c, under the parameters NGROUP or ISW(11) = "2". See Equations (4-2) and (4-3) in Section 4.1.2.

11. ERROR - STACK DIAMETER < = 0 FOR SOURCE n. Stack sources require a stack diameter greater than zero. Check the order of the input source deck.

12. WARNING - EXIT VELOCITY IS < = 0 FOR SOURCE n, PROG. SETS TO 1.0E-5 AND CONTINUES. The program sets a zero exit velocity for stacks to 1.0E-5, because it is used as a divisor in the plume rise equations. If you did not intend to set the exit velocity to zero for no plume rise, check the offending card and the order of the input source deck.

13. ERROR - SIGYO ≤ 0 FOR SOURCE n. Volume sources must have SIGYO greater than zero. Check the order of the input source deck.

14. ERROR - SIGZO < 0 FOR SOURCE n. Volume sources must have SIGZO greater than zero. Check the order of the input source deck.

15. ERROR - XO < 0 FOR SOURCE n. Area sources must have XO greater than ZERO. Check the order of the input source deck.

16. ERROR - SOURCE n LESS IN VALUE THAN LAST SOURCE n READ. Source input deck is out of order or miss punched.

17. ERROR - DISP CODE FOR SOURCE n IS OUT OF RANGE. The parameter DISP must equal 0, 1 or 2. Check card and order of input source deck.

18. ERROR - TYPE CODE FOR SOURCE n IS OUT OF RANGE. The parameter TYPE must equal 0, 1 or 2. Check card and order of source input deck.

19. ERROR - QFLG CODE FOR SOURCE n IS OUT OF RANGE. The parameter QFLG must equal 0, 1, 2 or 3. Check card and order of source input deck.

Where TAPEnn and TAPEmm are the names used on the tape REQUEST card and nn and mm are the logical unit numbers used to reference the input and output tapes, respectively. See the CDC FORTRAN Extended Reference Manual for your machine for variations in this card and alterations of this card by the LGO runstream card

- The program uses the END= clause in the read statement for card source input data

```
READ (IUNT, 9023, END = 1120) NUMS1, DISP. etc.
```

If your FORTRAN does not recognize this statement, remove the ",END = 1120" from this statement in sub-routine MODEL. Also, if this clause is removed from this statement, the user must insure the program never tries to read beyond the last input card source or the program will error off. Also, the END= clause is used in some of the tape read statements at program listing sequence numbers -- ISC08570, ISC16340, ISC16830, ISC16900, ISC17030, ISC18060, and ISC18330. If your FORTRAN does not recognize the END= clause, it must be removed from these statements. The removal of the END= clause from these statements will eliminate the capability of the ISCLT program in some cases to position a tape to the correct file via the input parameter NOFILE when multiple passes are required through the tape data. This problem can be overcome by writing the ISCLT output data to a mass-storage file and then copying the mass-storage file to an output tape file when the program has terminated.

- Two successive file marks are written at the end of execution. The program uses the FORTRAN BACKSPACE command to back the output tape back over the last end of file mark written. If your FORTRAN BACKSPACE command does not back over end of file marks, the tape will be left positioned after the second end of file mark at the end of execution. However, if the program must make multiple passes through the tape for the output reports, the tape will be left positioned after the first file mark at the end of the data set. The program will make multiple passes through the data file, if Condition c under ISW(11) or NGROUP does not apply to the run and Condition a was selected.

SECTION 5

REFERENCES

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